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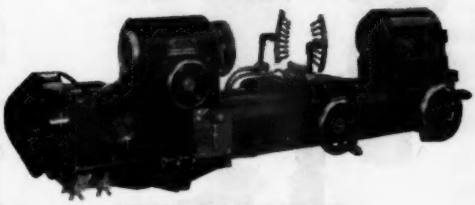

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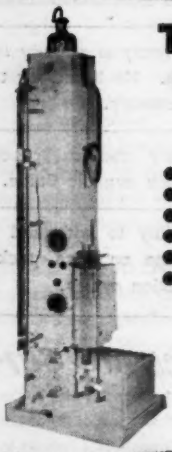

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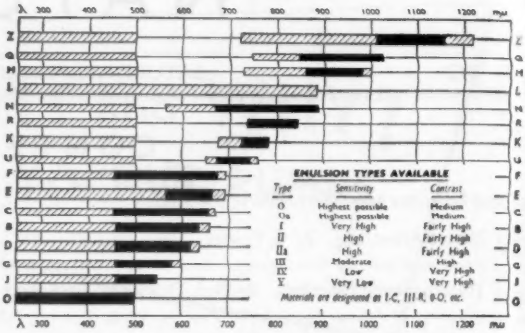

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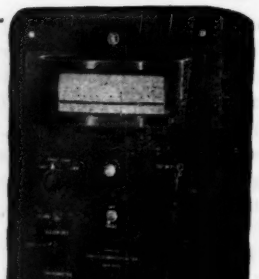

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POTENTIAL SCIENTISTS AND TECHNICIANS IN THE SCHOOLS

In its fifth annual report nearly three years ago the Advisory Council on Scientific Policy noted that prejudice against an industrial career and lack of knowledge of its opportunities on the part of both parents and teachers were responsible for robbing the nation of potential talent in science and technology. A recent investigation made by the Physics Department of the University of Bristol, and reported by Prof. N. F. Mott and N. Thompson in the *Universities Quarterly*, on those candidates for admission to the honours school of physics there who are not accepted, suggests that, of the boys with ability but no inclination to study science to be found in the arts sixth forms, some at least might have chosen to study science if they, their parents and their headmasters had been fully aware of the need of the community for well-educated scientists and the opportunities open to such men. The seriousness of such ignorance has, however, usually been emphasized more particularly in respect of the shortage of scientists than in regard to scientific and technical man-power generally. The Parliamentary and Scientific Committee, it is true, in its memorandum on Higher Technological Education issued last July, commented on the importance of creating a bigger demand from the school population of Britain for education in science and technology, and in opening a debate on this memorandum in the House of Lords on December 7, Lord Glyn affirmed that many promising pupils in the secondary schools are discouraged from technological studies. Lord Salisbury stated in that debate that about two-thirds of the boys in the sixth forms of grammar schools as a whole are taking science as their main subject of study, and that, of the eight thousand State scholars in the country, some five thousand are studying science; but he agreed that all possible steps should be taken to attract a good proportion of the ablest boys and girls to a scientific career.

Nevertheless, a committee on the Shortage of Science Teachers, set up by resolution of a conference convened by the Federation of British Industries in January 1954, reported that probably the most important untapped source of potential science graduates is to be found among the able pupils who leave the grammar schools at sixteen. That committee expressed the hope that the schools, with the full support of the local education authorities, would succeed in convincing these boys and girls and their parents of the value of the sixth-form course and thus prevent this waste of ability. Since then, a report published by the universities committee of the Association of Scientific Workers, based on a questionnaire sent to 303 secondary grammar schools, direct-grant schools, and independent schools, has suggested that an increase of at least twenty per cent, and even up to fifty per cent, in the number of suitable science students at the universities is possible if all suitable grammar school boys and girls could be persuaded to complete a sixth-form course. At present, twenty-one per cent of those who left local education authority schools and fifteen per cent of those who left independent and direct-grant schools would, in the opinion of their teachers, have benefited from the sixth-form course; while thirty-two per cent of those in science sixth forms in local education authority schools and twenty-three per cent in direct-grant and independent schools left to take up jobs when, in the opinion of their teachers, they should have proceeded to universities.

This estimate has now been endorsed by the broader and more systematic study of premature school-leaving in England undertaken for the Minister of Education towards the end of 1952 by the Central Advisory Council for Education (England) (see also p. 331). The inquiry was to consider what factors influenced the age at which boys and girls leave secondary schools which provide courses beyond the minimum school-leaving age in Britain (at present fifteen); the extent to which it is desirable to increase the proportion of those who remain at school, particularly the proportion of those who remain at school to the age of about eighteen; and the steps to be taken to secure such an increase. Broadly speaking, the report of this inquiry*, which is based on a ten per cent sample of maintained and direct-grant grammar schools in England, fully establishes that while the practice of early leaving is declining, there is still an important leakage of potential scientists. Of the grammar school intake of 1946, in addition to about 10,000 boys and 7,000 girls who took advanced sixth-form courses, there were in addition about 5,000 boys and 5,000 girls with the capacity to do so if they had stayed longer at school, and of those some 2,900 boys and 1,300 girls would have been suited for courses in mathematics and science. If all these boys and girls had completed advanced courses, the number of boys taking sixth-form courses would have been increased by about half, and the number of girls by about two-thirds.

Nevertheless, the value of the report lies not so much in its demonstration of a loss of at least 4,000 potential scientists or technologists—including science teachers—as in its clear presentation of the factors that require consideration in determining either immediate action or long-term policy. The Council's estimate that less than half the present intake into grammar schools could profitably take sixth-form courses is a reminder of the need both for action to prevent waste of public expenditure and for caution

* Ministry of Education. Early Leaving: a Report of the Central Advisory Council for Education (England). Pp. vii+99. (London: H.M. Stationery Office, 1954.) 3s. 6d. net.

in deciding on the measures by which the leakage of talent is to be checked.

The Council's attitude to the extension of the school life beyond sixteen is thoroughly realistic. It rejects as inadequate by itself both the approach which asks whether continued education will assist a child to develop more fully as an individual, and also that based on whether it will fit him or her for the work he or she may be called upon to do later in life. "A child," it says, "must grow up into the community and adjust himself to its economic demands and moral obligations; and it is wrong to create the illusion in the child's mind that he has the right to demand from it the kind of life that pleases him or will give him the greatest scope for self-expression regardless of the needs of others." That was worth saying to-day. But the report continues: "a citizen's economic role is not his whole life . . . no economic system will ever be so organized that everyone will use his whole talents in his employment . . . education must not confine itself to cultivating those abilities which may be economically useful but should be given in good measure to develop the whole man".

The Council, accordingly, suggests that academic ability should be the first determining factor. If the interest of a pupil flags as the work of the school in the upper forms calls for increased power of abstract thought beyond his or her capacity, the school should not try to persuade the pupil to stay. Nor should it seek to retain those in whom school life produces a real and continuous sense of frustration.

The Council thus recognizes that there are some boys and girls who, because of their intellectual or emotional characteristics, should leave school before they are eighteen: these may well be the school leavers which industry, as the Federation of British Industries has recently pointed out, should be seeking more actively to recruit. While satisfied that there is enough academic ability to justify an increase in the number of boys and girls following advanced courses by about a half and two-thirds, respectively, the Council is dubious as to the wisdom of enforcing generally a leaving-age of sixteen or even a statutory differential leaving-age for grammar schools. The significant reduction in early leaving manifest in recent years does indeed suggest that ultimately, as the educational changes of recent years have their full effect in the homes, some of the factors which at present encourage early leaving will lose force. Nevertheless, the Council is not content to rely on such long-term tendencies, and if only as a contribution towards meeting the present national need for scientists and technologists, its proposals, though somewhat tentative, should receive vigorous support.

Those proposals are already being considered by Sir David Eccles, as he indicates in his foreword, and the reservations he obviously has are rather on the financial side. Sir David takes the reasonable view that the main purpose of any increased maintenance allowances, such as the report recommends, should be to help the right pupils to stay at school—to give help where there is both need and merit. Whether an all-round increase in the proportion of grammar school places is desirable is less certain, and the Council makes some comments on the importance of developing courses both in modern schools and in technical colleges and other institutions as alternatives to sixth-form work; the implications of these proposals require fuller examination than they are given in this report.

The report is, as so often happens, stronger in diagnosis than in the prescription of remedies for what is wrong. It suggests, for example, that more opportunities for transfer from modern schools to grammar schools are required, but without examining in any detail the difficulties involved, or discussing the reverse process. It has little to say about the ways in which the parental attitudes could be changed, although unfavourable home influence is a decisive factor here, as it is also the main cause of the waste of talent through early leaving.

On that point the report provides clear evidence, though the reasons why the middle classes make the best use of educational opportunity are by no means equally clear; the report itself suggests that more precise study of home backgrounds in relation to education is much needed, particularly of the effect of the home background of the semi-skilled and unskilled worker upon a child's education at a grammar school. Children from professional and managerial families account for 15 per cent of the school population, but for 25 per cent of that of the grammar schools and for 43·7 per cent of the sixth forms. Not only is the performance of such children in the selection tests at eleven better, but also they stay at school longer and they do better at the grammar schools. "From the children of parents in professional or managerial occupations at one extreme to the children of unskilled workers at the other, there is a steady and marked decline in performance at the grammar school, in the length of school life, and in academic performance at the time of leaving. This is not a mere development of the better performance at the age of eleven of children in certain groups; it reflects a widespread changing of places in academic order between eleven and sixteen or eighteen."

As a corollary it follows that the risk of waste of public money in fees and maintenance allowances increases as performance declines in this way. This is no argument for reserving a proportion of grammar school places for those whose parents are willing to pay fees—a suggestion firmly rejected by the Council—though it suggests that it is wise to take account of the fact that there are some boys and girls whose outlook and lives are dominated by the traditions of their family, and by friends favouring early earning and independence and opposed to a long school life. The Council wisely observes that care should be taken not to handicap further the children of unskilled workers who are most subject to such influences. This influence and outlook are bound to be affected by changes in the education which the parents themselves have received. "The effect on

the grammar schools of the changes introduced in 1944 will not be properly seen until the boys and girls affected by them in their school days themselves have children of secondary school age."

Apart from this, the report also makes clear that shortage of money is in itself a less common reason for leaving than some others. Financial considerations, however, affect the decision to leave for an appreciable number of children, especially among those of semi-skilled and unskilled workers, and for this reason the Council concludes that the existing schemes of aid are not fulfilling their function and that there is a clear case for improvement, either by increasing the rates of grant or extending the parents' income-range, or both. The Council did not examine the financial implications of its proposal, nor has it fully explored the social or political implications, though the complexity of the problem is clearly indicated.

Perhaps understandably enough, the Council was reluctant to grapple with the implications of this forthright demonstration that, in education and in life, heredity and environment do, after all, matter a great deal. It was not expected of the Council that it should express an opinion as to whether it is more in the public interest to remove all handicaps to the development of every outstanding intellect or to make sure that every mediocre intellect has a chance. It has at least suggested some practical steps for making the dilemma less acute; but none the less, in doing so, it might have been expected to face more fully the minor dilemma which arises when it considers the immediate action required to stop the leakage of potential scientists.

There can be no doubt that it would be worth taking all possible steps to obtain even half the additional scientists which the report suggests are being lost each year. The report gives no indication as to how this should be done, though it would seem that the most obvious measures are those already suggested by the Advisory Council on Scientific Policy, and which for a different purpose the Federation of British Industries has already begun to apply —publicity and persuasion. Even here the implications seem to merit a little closer examination. The report points out that if we succeed in inducing more boys and girls to stay on in the sixth forms, whether the science sixth or not, they will, *ipso facto*, be diverted from other careers; and such evidence as this inquiry has yielded suggests that most of them will be diverted from some sort of clerical career, apprenticeship or laboratory work.

For the first two groups the maximum numbers would be no more than about one-seventh or one-eighth, even if all the qualified boys and girls were diverted to more advanced forms of training, and the Council admits that it is desirable that some such boys and girls, if not the most intelligent, should follow these types of career. There are other bodies, such as trade unions, besides industrial firms, which should welcome this source of recruitment of potential leadership. The loss among laboratory technicians is more serious, not simply because quantitatively it may amount to some thirty-six per cent, but also because of its bearing on the efficient use of existing scientists and technologists. This aspect is dismissed too cavalierly by the Council. It may be wasteful to employ as technicians boys and girls capable of qualifying as first-class scientists and technologists; but it is equally wasteful to employ a trained scientist or technologist on duties which could be carried out equally well, and perhaps better, by a less highly trained technician. The Council, in fact, scarcely seems to appreciate the extent to which the work of the laboratory technician demands skill and intelligence, or the imperative need at the present time of making the utmost use of the services of technicians to relieve the existing shortage of scientists and technologists.

That has been repeatedly emphasized in recent discussions on the shortage of science teachers in particular, for example, by Dr. Eric James at the conference of the Universities of Great Britain and Northern Ireland last December, when he asked whether industry is using its scientists efficiently; and it has always been recognized in discussions on the expansion of higher technological education that many more technicians than technologists and scientists will always be required. More harm than good may well be done if attempts to persuade boys to stay on in the science sixth to take up a career as scientist or technologist, following a course at a university or a college of technology, convey the impression that that of technician is of low esteem or in any way less important. It is at least for consideration that for some boys and girls a period in the science sixth may be the most appropriate prelude to a career as a laboratory technician, and the Council suggests generally that professional bodies and employers could alter their conditions of entry to encourage staying at school until eighteen.

Any approach to parents or to teachers suggesting a national need for a particular kind of talent is open to the implication that other careers, though less exacting intellectually, are inferior in either importance or esteem. Such an approach may well be the most promising immediate step, but it should be supported by those auxiliary means of helping the child handicapped by home conditions, such as providing opportunities for evening study in the public libraries or schools, which the Council suggests. In such matters the Minister of Education's influence could be decisive, and it is to be hoped that controversy over the more dubious financial proposals will not distract attention from such immediate ameliorative measures. Ultimately, as the report makes plain, the solution lies with public opinion, within and without the home, and one step which scientists and technologists themselves could take is to press for some reasonable and authoritative estimate of the nation's requirements for technicians in relation to the need for scientists and technologists. Such an estimate, based on a realistic conception of the efficient use of trained man-power, is an essential basis for any publicity on a national scale, or approach either to parents or teachers, in terms of the national need for such talents.

HENRY EDWARD ARMSTRONG

Henry Edward Armstrong

Educational Work. By Charles E. Browne. Pp. xiii+26+4 plates. (London: Christ's Hospital, 26 Great Tower Street, E.C.3, 1954.) 6*s*.

THE title of this book is too comprehensive for the restricted scope of its contents. A volume so slender can tell us little about its subject and less about his extensive educational work. 'H. E. A.', a man of remarkable personality, great vitality and vigour of mind, a prophet and a visionary, besides being a deep and versatile scholar of critical outlook and independence of thought, was a prolific writer and forceful speaker and had a rare gift of expression. Conscious of a mission and burning with the fiery zeal of reform, he marshalled his great gifts and directed his efforts towards improving science teaching in the schools of Britain, and arousing and educating the public to a realization of the ever-increasing influence of science in human affairs.

A fearless advocate of the causes he had at heart, he was an indefatigable educator and reformer. His weapon was the strength of his arguments, clearly and persistently put forward; his weakness, his use of biting wit and bitter comment. For he made little use of patient persuasion and delighted in stinging his audience. He admitted the unpleasantness of his methods, necessary, he maintained, to arouse people out of their apathy and indifference and make them think. Supineness and complacency, whether in a community or a person in authority, roused his wrath. He was the stormy petrel of every committee on which he sat, the terror of editors of scientific journals, and the critic of everyone straying from the path of the scientific method.

By his articles and letters to the Press, Armstrong attempted to educate the public on scientific matters. He exhorted farmers to study the cultivation of sweet grass and repeatedly pointed out the health value of pure milk and wholesome bread. Ahead of his time, he urged that the scientific method should be applied to the exploitation of the Coal Measures of Britain. Again, he brought forward strong arguments for making a survey of the world's resources. His edifying addresses to professional chemists—critical, hortatory and inspiring—are as pertinent to-day as when they were written. Many pupils who owed their chemical education to him later became distinguished university professors. The booklet under review has of necessity little mention, not to speak of expansion, of the above educational activities.

From the storm and turmoil of heated controversy, Armstrong seems to have found a psychological rest in his service to Christ's Hospital. He was a governor of this old and richly endowed London school for more than forty years, and was influential in getting it removed to Horsham in Sussex. There, amid ideal surroundings, with spacious well-equipped laboratories, very small classes and a specially selected staff, all due to his initiative and drive, he was able to get science taught in a way dear to his heart. The boys were trained in the art and method of discovery, and learned only what could be argued from experiments carried out by themselves, a method of teaching later called 'heurism'. Most of the text and all the illustrations of the booklet are concerned with this phase of Armstrong's educational work. Sir William Hamilton Fyfe, headmaster in Armstrong's day, contributes the charming and laudatory prologue; in the epilogue, Dr. G. van Praagh, the present senior science master, in summing up the "Heuristic Method To-day", has nothing to add to what is already known. The author, the chief member of the science team collected by Armstrong, pays a pious tribute to his old master, and is warmly appreciative of the work he did for Christ's Hospital. The book should delight the 'Old Blues' who came under the influence of 'H. E. A.', and should help to keep fresh the memory of one who did his utmost to urge scientists to make ceaseless effort.

G. Fowles

THE INTERACTION OF SCIENCE AND SOCIETY

Science in History

By Prof. J. D. Bernal. Pp. xxiv+967. (London: C. A. Watts and Co., Ltd., 1954.) 42*s*. net.

NEITHER of the two terms occurring in the title of this volume must be taken in the strict sense tradition attributes to them, in which science means natural science only and history is exclusively related to the irrevocable past. Science here covers social sciences as well, and the history that is told extends to the date of publication of the book.

One need not read far to become aware of the motives prompting the author to take this broad and comprehensive view of his subject. It was not his intention to deal with history for history's sake, but as a means of understanding the interaction of science and society, the importance of which is so conspicuous in these days and will surely become still clearer in the future. Accordingly, the historical approach plays the part of an introduction, and the author's aims would have been wholly thwarted if he had stopped short at the end of the nineteenth century, where as a rule works on the history of science have their time limit.

There is another thing which is clear to the reader from the very beginning of the book, namely, that the author considers the vicissitudes of science in the past and present from a deliberately Marxist point of view. He is convinced that not only the means used by scientists in their researches but also the guiding ideas of their theoretical approach are conditioned by the events and pressures of society; that scientific problems are set in the first place by actual economic necessity, and only in the second place do they arise out of earlier scientific ideas; that a new economic system inevitably involves a different experimental science; that history has to be interpreted in terms of economics only and that consequently science in each period of its development has to be treated as a social and economic phenomenon.

In my opinion, this way of looking at the history of science means that an undoubtedly important aspect of development, namely, the indisputable relations between science and society, is unnecessarily made absolute, and raised to a status of uniqueness, with the neglect of numerous other equally important influences. Nevertheless, I must acknowledge the excellent manner in which the author acquits himself of the task he undertook. His mastery of the most diverse subjects in the history of science and in its present phase deserves the highest admiration. The way in which he expounds his views is perfectly clear. As he avows

his political ideas without any reserve, he is likely to hurt many a reader's feelings. This, however, should not be a reason for leaving the book unread. As the views developed are highly important and influential in these days, one will only harm oneself by not seizing the opportunity of seeing them defended in so masterly a fashion. As to the hurt, it will have to be taken into the bargain.

It would, of course, be quite out of place to direct the attention to some minor historical errors occurring in the work, the more so as they do not invalidate the theses sustained. E. J. DIJKSTERHUIS

HIGHER TRANSCENDENTAL FUNCTIONS

Higher Transcendental Functions

Based, in part, on notes left by the late Prof. Harry Bateman, and compiled by the Staff of the Bateman Project. Vol. 1. Pp. xxvi+302. 52*s*. Vol. 2. Pp. xvii+396. 60*s*. (London: McGraw-Hill Publishing Company, Ltd., 1953.)

THE rapid growth of mathematical knowledge and the multiplication of mathematical journals throughout the world make it increasingly difficult for the mathematician to keep abreast of his subject. For this reason the great project, first proposed by the late Prof. Harry Bateman, and so ably being carried out by Prof. A. Erdélyi and his colleagues, will earn the gratitude of great numbers of mathematicians, pure and applied. These two volumes, apparently to be followed by others, cover an extremely wide range. They contain thousands of formulæ, usually with some indication of origin, and frequently with suggestions as to methods of proof. At the end of each chapter is to be found a most useful list of relevant papers and books.

The first chapter deals with the gamma and beta functions, the second with the hypergeometric function. This is naturally followed by a chapter on the Legendre functions. It seems a pity that the authors did not take the opportunity, in this chapter and elsewhere, of giving a lead out of the morass of notations, so confusing to the student. For example, it is unfortunate that the notations $P_\nu^\mu(z)$, where $|z| > 1$, and $P_\nu^\mu(x)$, where $-1 < x < 1$, should refer to two different functions. After all, z can be replaced by $x(> 1)$ in the first function, and there is no reason why the argument of the second function should always be real. It is a simple matter to denote the second function by $T_\nu^\mu(z)$, as mentioned on page 179, and so avoid all ambiguity. It is high time also that Hobson's unfortunate notation for $Q_\nu^\mu(z)$, involving a factor $\exp i\mu\pi$, should be discarded. This factor was introduced to make the definition consistent with the definition when μ is a positive integer; namely,

$$Q_\nu^\mu(z) = (z^2 - 1)^{\frac{1}{2}\mu} \frac{d^\mu}{dz^\mu} Q_\nu(z).$$

In order to avoid the complex factor, Barnes replaced it by the factor $\sin(\mu + \nu)\pi/\sin(\nu\pi)$, thus ensuring that the function should be real for z real and greater than unity, but unfortunately making it vanish identically or become non-existent for certain values of μ and ν. The simplest thing to do is to insert a factor $(-1)^\mu$ on the right of the equation above, and then these troublesome factors are not required.

Again, it seems scarcely necessary nowadays to stress the Gegenbauer polynomials, as these can be expressed in terms of associated Legendre functions.

The fourth chapter deals with various types of generalized hypergeometric functions, and the fifth with E-functions, Meijer's G-functions and generalized hypergeometric functions of two variables. The E-functions have proved a powerful instrument in evaluating integrals involving Bessel, Legendre, confluent hypergeometric and other functions. The G-functions are generalizations of the E-functions, and their properties have been worked out with signal ability by Meijer. Their usefulness as an instrument of research has yet to be demonstrated. The final chapter of the first volume contains an account of the confluent hypergeometric function.

The second volume has chapters dealing with Bessel functions—naturally at considerable length—parabolic cylinder functions, incomplete gamma functions, orthogonal polynomials, spherical and hyperspherical harmonic polynomials, and orthogonal polynomials in several variables, and closes with a long account of elliptic integrals and functions. These should provide a valuable armoury for the research student. Here again something might have been done in the matter of notation. Nothing is gained by retaining the two Hankel functions $H_\nu^{(1)}(z)$ and $H_\nu^{(2)}(z)$ when one function only is required. Dougall's function $G_n(z)$ is simpler and more closely related to Macdonald's now generally accepted function $K_n(z)$. This latter function should be known as the modified Bessel function of the second kind—not of the third kind. One wonders, too, if the authors were unaware of the origin of the very general formula for the product of two Bessel functions at the top of page 48. It first appeared in the *Proceedings of the Edinburgh Mathematical Society*, Series 2, Vol. 2.

In spite of these criticisms, we congratulate the compilers on a great achievement. No university or scientific library will be complete without having these volumes on its shelves. THOMAS M. MACROBERT

THE 'CHEMISTRY' OF ATOMIC NUCLEI

Nuclear Species

By Prof. H. E. Huntley. Pp. xix+193. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1954.) 21*s*. net.

PROF. H. E. HUNTLEY has written an attractive elementary account of what may be called 'nuclear chemistry'. Just as the atomic shell model did for chemistry, the nuclear shell model is beginning to explain the more obvious facts of his subject. The author seems to think that a nuclear physicist should know his nuclei just as an inorganic chemist must know the properties of the elements, and of course there is everything to be said for this. But the subject is a wide one, namely, that covered by what is usually known as 'nuclear physics', while the book is mainly concerned with properties of the stable nuclei. It is true that there are references to radioactive nuclei, but many of their properties (for example, the characteristic features of β-emission) are not included. Since also the treatment of excited states of nuclei is rather sketchy, the subject-matter is largely confined to stable nuclei in their ground states. This subject is handled in a comprehensive and clear manner.

But Prof. Huntley, in his preface, says that the book "is primarily intended for aspirants to University Honours". Personally, I do not think it would be practicable to introduce his subject-matter in so much detail into a crowded university honours course, because, after all, it is only a part of nuclear physics. However, I would encourage any undergraduate or postgraduate student to read the book as part of his all-round education. From this point of view it is perhaps a pity that the author has loaded the book with descriptions of more or less elementary background material (even, surprisingly, of the Michelson–Morley experiment). Such matters are not adequately dealt with from a student textbook point of view and might well have been taken as read. In place, though the author's charts of isotopes are excellent, I would have liked to see the inclusion of a table of all the known nuclei (stable and unstable) such as the Seaborg–Perlman table of isotopes.

In spite of such criticisms, I am sure that Prof. Huntley's book should be on the shelves of all physics libraries, since it undoubtedly contains a great deal of interesting material not available elsewhere in concise form. H. W. B. Skinner

SHRUNKEN HEADS

Amazon Head-Hunters

By Lewis Cotlow. Pp. 208+17 plates. (London: Robert Hale, Ltd., 1954.) 18*s*. net.

THE author of this book is a New York insurance broker whose hobby is travelling in lands inhabited by primitive races. He is an expert photographer, and on his journeys he has sometimes had the aid of professional ciné-photographers. His African film entitled "Savage Splendour" was a success. Between 1940 and 1949 he made several expeditions to the north-west of the South American continent, from which rise the head-waters of the Amazon, and to country farther north around the Isthmus of Panama. These are the areas inhabited by the Choco, Colorado and Yagua Indians, and include also the very isolated country of the Jivaro Indians, who are especially known for their custom of drying and shrinking the heads of their enemies. The author has prepared commercial films relating to these journeys, and he has lectured much on his experiences. This book gives a connected story and makes most interesting reading. It contains a great deal of first-hand material which is of value to the anthropologist.

While most of the tribes visited by the author are quite 'unspoiled' by contact with civilized peoples, the scientist will no doubt find his most interesting material in the sections which deal with the Jivaro Indians. Mr. Cotlow was able to become very friendly with several of their chiefs, and they informed him of the number of heads which they had taken during their lives. He brings out forcibly the fact that the relatives of a man slain in battle are in honour bound to kill his killer and to shrink his decapitated head. The relatives of this victim must retaliate in the same manner, so that inter-community warfare is almost continuous. The author describes fully the method of shrinking a head. Unfortunately, he did not actually see it carried out, since at the time of the raid he was stricken with dysentery. He did see and photograph the victory-dance which followed the exploit. He also describes in detail the making of the fine blow-guns which are used by the Jivaros. He frequently watched the use of the curare-tipped darts in killing animals. Birds died at once; monkeys survived between two and four minutes. Larger animals were only irritated by these poisonous darts. The author describes the use of the pincers of living ants for the purpose of suturing wounds. He also describes an attack by the tiny, yet much dreaded, canero fish which embeds itself in the natural orifices of the body. His comments on the food of the Indians are illuminating; for example, monkey stew he found not unacceptable, until he noticed a tiny hand floating in it. During one of his trips to the natives he was made a blood-brother of the tribe, and it took him a week to remove the paint.

This interesting and entertaining book is written modestly and without literary embellishment. The author's sympathy with the Indians is apparent on every page. E. Ashworth Underwood

BIOCHEMISTRY OF CANCER

Biochemistry of Cancer

By Jesse P. Greenstein. Second edition. Pp. xiii+653. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1954.) 12 dollars.

CANCER research and biochemistry are both wide and rapidly growing fields of study, so that Dr. Greenstein has a wealth of material to discuss in this work. He ranges from the study of theoretical chemistry in relation to structure of cancer-producing compounds to the structure of virus particles which can transmit malignant disease and the genetic factors in cancer.

Dr. Greenstein, who is chief of the Laboratory of Biochemistry in the National Cancer Institute, Bethesda, Maryland, performed a most useful service to cancer research workers and biochemists when he published the first edition of this book in 1947. Since then many new facts have been discovered and hypotheses advanced, and these have been incorporated into the new edition by rewriting most of the book. The work is divided into three main sections—the induction of cancer; attempts at control of tumour induction and tumour growth; and the properties of tumours.

The processes of induction of cancer by viruses, hormones, hydrocarbons, aromatic amines, aliphatic halogen compounds, metals, alkylating agents and radiations are all considered. The section on control of cancer induction and growth is still the smallest; but it has increased in size relatively much more than the other parts of the book since the first edition. The last section, dealing with the chemistry and biochemistry of tumours and tumour-bearing hosts, occupies about half the book and is the field in which the author has made his own distinguished contributions. This section is unique, as no other modern comparative account of the different properties of tumours is available.

This new edition should be a great help to cancer research workers; it would be even more valuable if the index were more complete and detailed. Biochemists working in fields outside cancer research should find this monograph of interest.

E. Boyland

THERMONUCLEAR EXPLOSIONS AND THE WEATHER

By Sir GRAHAM SUTTON, C.B.E., F.R.S.
Director of the Meteorological Office

THE poor weather experienced in the British Isles and generally in western Europe in the summer of 1954 came soon after the announcement by the United States Atomic Energy Commission that a series of thermonuclear explosions had taken place in the Pacific. Perhaps not unnaturally, this coincidence caused speculation (unfortunately, often ill-formed and emotional) on the possibility of 'cause and effect'. The present article is an attempt to examine objectively if any grounds exist for suspecting a unique relationship between the man-made disturbances over the Pacific and the weather of mid-1954 in other parts of the world.

Such an investigation is difficult for a variety of reasons. Weather is the first-order perturbation of climate and since (as shown below) the weather of 1954 did not exhibit, in the British Isles, any features that cannot be paralleled and even exceeded in past years, it follows that any effects attributable to the explosions must be of magnitude not exceeding that of ordinary weather-producing influences. The detection of such additional effects, therefore, demands careful statistical analysis that cannot properly be attempted until several years have elapsed, so that existing climatic 'trends' (see below) can be recognized and eliminated. An equally serious difficulty is that, so far, it is not known with certainty how many thermonuclear explosions occurred in 1954, or when and where they all occurred. From Press reports, it is possible to make what is thought to be a reasonable estimate of the order of magnitude of the energy release in the largest of the Pacific explosions; but almost all other details are lacking.

These factors, combined with present uncertainty concerning the mechanism of many fundamental atmospheric processes, such as the formation of depressions and the precipitation of water, make it impossible to give a rigorous demonstration of the truth or falsity of the proposition that thermonuclear explosions were responsible for, or even contributed materially to, the poor summer of 1954 in western Europe. At this stage the most that can be attempted is an examination of the plausibility of what is, for many people, a firmly held belief.

Evidence from Meteorological Records

In the British Isles the summer (June, July and August) of 1954 was cool, wet and dull. In England and Wales, in eighty-four years of comparable records there have been only six wetter summers; but in Scotland twenty-five summers gave a greater total rainfall. No rainfall records were broken or even approached—1879 and 1912 had each about 4 in. of rain in excess of the total, for the whole country, of nearly 12 in. for the past summer. At Kew (for which station the records are unusually long and reliable) 1954 with a total of 9·5 in. for the summer falls far below the record year, 1903, in which 15·4 in. fell in the three summer months. In the present century alone, 1924, 1927 and 1946 had each more wet days in summer than 1954.

The season was decidedly cool, and of the past fifty-three summers only two, 1907 and 1922, had lower mean temperatures in England and Wales. Sunshine also was lacking, and the only summer with a worse record in this respect since 1906 was 1912 (also a year with a wet summer).

In Western Europe, weather was generally cooler and wetter than usual; but there were notable exceptions. June temperatures were above average in many parts, and in July, France had less than the normal rainfall. In the United States and in the U.S.S.R. (so far as records are available) the summer was, on the whole, warmer than average and in the United States it was somewhat drier (July 1954 was, in fact, one of the hottest months ever recorded in the central United States). South and west Africa had wetter and cooler seasons than usual and Indian monsoon rains were generally above average. Rainfall was also above average in Japan and Malaya.

The world-weather picture of mid-1954 is thus complex, but not more so than usual. The most striking feature is that large areas of the globe experienced more cloud and rain and were somewhat cooler than would be expected from long-term averages.

The climatological pattern for the British Isles in recent years has been examined by Dr. J. Glasspoole, head of the British Climatology Branch of the Meteorological Office, in a paper shortly to appear in the *Meteorological Magazine*. The climate of these islands, as indicated by long-term averages, is very stable; but over any period of years there are definite oscillations (called 'trends' by meteorologists) of variable length and amplitude. Such major oscillations are clearly shown when yearly variations are minimized by plotting 10-year moving averages. The curves so obtained show maxima and minima at irregular intervals; for example, the 10-year moving averages of summer temperature for England and Wales during 1901–53 begin well below the mean line, increase fairly rapidly and rise above the mean in the periods 1922–31 to 1929–38 and are now descending. The corresponding rainfall curve shows a pronounced maximum in 1873–82, which has not been reached again; but the curve, after some smaller oscillations about the long-term mean, is now ascending. The current trend in summer sunshine is also towards lower values.

These results suggest (but do not positively demonstrate) that the weather of the past summer continues a general trend that has been indicated for some years past. This suggestion cannot be properly examined until future years have produced more observations; but at least it indicates the possibility that cool wet summers will not be infrequent for some years to come. It should be pointed out, however, that such 'trends', although of great interest to the climatologist, are of little or no value as a basis for long-range forecasts, and it is possible for the summer of a single year (such as 1955) to be warm and dry without affecting significantly the general

character of the current trend. In the present connexion the analysis may be significant in that it suggests that the summer of 1954, although extreme, did to some extent conform to an existing pattern and therefore need not have been influenced by artificial causes.

The anatomy of the pressure field during the summer reveals some interesting features. Two types of patterns dominated: one in which depressions approached the British Isles from the north-west (this type was persistent in a period near the end of June and the early part of July) and another (chiefly responsible for the large rainfall totals in southern England in August) characterized by the approach of depressions from the south-west. Examination of 5-day means for the northern hemisphere indicates that a pattern with three major long waves was established before the beginning of July and persisted through much of August.

Present-day knowledge of the general circulation, and of the mechanism of the formation and steering of the large slow-moving disturbances of the atmosphere over the Atlantic, is inadequate to relate such patterns to isolated large displacements of air occurring in, say, the Pacific. However, the relative stability and persistence of the patterns do not suggest a unique connexion with explosions. Left to itself, the kinetic energy of an atmospheric disturbance is reduced fairly rapidly by eddy friction, and Brunt[1] has estimated that in these conditions the general circulation would practically cease in less than a week. Press reports indicate that there must have been intervals of some weeks between the known explosions, and it may therefore be supposed that the direct effects of the trials would be felt as isolated bursts of bad weather with intervening settled spells. Actually, the unsettled showery type persisted throughout the summer, and there were no well-developed spells of fine weather in the British Isles.

Thus both the climatological and aerological evidence are unfavourable to the suggestion that thermonuclear explosions, so far as they are known to have occurred, ruined what might otherwise have been a fine summer. The weather experienced in the British Isles was well within the established climatic range, and taking all facts into account, it is evident that it would be exceedingly difficult, if not impossible, to establish a 'cause and effect' sequence on purely meteorological grounds. What evidence exists points, in fact, to the opposite conclusion.

Dates and Orders of Magnitude

The difficulties of direct investigation of the effects of thermonuclear explosions, intrinsically very severe, are enhanced by lack of information concerning the events. The earliest thermonuclear trial seems to have been that conducted at Eniwetok in November 1952, which was declared by President Eisenhower on March 12, 1953, to have been a full-scale 'hydrogen' explosion. On August 20, 1953, *Pravda* stated that "a few days ago one of the types of hydrogen bomb was exploded". This was confirmed by the U.S. Atomic Energy Commission on the same day, and the actual date was given as August 12, 1953; but no information has been published concerning the place of the trial or the magnitude of the energy release. On March 1, 1954, the Atomic Energy Commission announced that an 'atomic device' had been detonated in the Marshall Islands, and on March 29, 1954, Admiral Strauss referred to this as a "thermonuclear device", adding that a second thermonuclear explosion had been set off on March 26. Finally, on May 13, 1954, Admiral Strauss announced the completion of a series of tests in the development of thermonuclear weapons; but the number and dates of the events have never been announced.

It is seen from the above that the known thermonuclear explosions have extended over a considerable period of time, with presumably a maximum frequency in the spring of 1954. Statements by the U.S. authorities indicate that at least one explosion was about six hundred times as powerful as the Nagasaki bomb. This indicates an energy release of the order of 10^{16} gm. cal. Shaw[2] has estimated that the kinetic energy of an average cyclonic disturbance, 10 mb. deep and 1,400 km. diameter, is about $3 \cdot 5 \times 10^{16}$ gm. cal., and Brunt (quoted by Shaw) has calculated that the kinetic energy of the general circulation of the atmosphere is of the order of 7×10^{19} gm. cal. Thus the energy release in what is thought to have been the most violent explosion to date is equivalent to the addition of one rather small depression to the atmosphere, or to an increase of the kinetic energy of the whole circulation by slightly more than one part in ten thousand, assuming that the whole of the energy released appears as energy of motion. Atmospheric turbulence has been estimated by Brunt to dissipate kinetic energy at about 1 gm. cal. per square metre per second, so that those who seek support for the theory that the effects of the explosions were felt all over the world in increased cyclonic activity, lasting for many months, are faced with a difficult task. Even in the case of the largest volcanic explosions, any strengthening of the general circulation is not detectable more than six months after the event[3]. It seems that the only really hopeful line of support for such theories is to be found in the examination of subsidiary effects, such as the action of dust, and that the direct dynamical consequences must have been confined to the vicinity of the trials.

Possible Effects of Dispersed Debris

The theory that volcanic eruptions, by ejecting immense clouds of finely divided matter into the upper atmosphere, can cause notable changes in the amount of solar radiation reaching the surface of the earth and are usually followed by cool, wet weather or even severe winters, was advanced by the late W. J. Humphreys and given much prominence in his well-known book "The Physics of the Atmosphere". Two possible examples taken from the climatic record of Great Britain are 1903, which was preceded by the eruption of Mt. Pelée in 1902, and 1912, which coincided with the eruption of Katmai (Alaska). Both these volcanoes are well placed to cause pollution of the upper atmosphere over Europe. Humphreys's theory has not found universal acceptance among meteorologists and there is little direct evidence of notable climatic effects from the dust clouds. Thus Shaw[4], after pointing out that "the additional short-wave radiation that reaches a horizontal surface in consequence of the scattering by dust particles seems to go some way towards compensating the surface for loss of direct radiation on account of obstruction by the dust", states that 1912 showed a more abundant supply of solar

energy at South Kensington than did the years immediately preceding and following the eruption of Katmai.

The amount of debris thrown into the upper atmosphere by the Pacific explosions was almost certainly less (probably by several orders of magnitude) than that ejected in the Krakatoa explosions. There is no evidence of abnormal weather in England following this eruption, although the optical effects of the dust were evident all over the world. At Pavlovsk, the Katmai eruption may have been responsible for a reduction of about 20 per cent in the solar radiation, and Kimball's analysis indicates that the total radiation received on a horizontal surface at Mount Weather in the months following the same eruption was, on the whole, about 5 per cent below that of the following year. Brooks[5] concludes that the only appreciable climatic effect of volcanic dust is a general cooling; but it is obvious that such effects can be detected only with the largest eruptions. As solar radiation records generally show considerable 'noise', it seems likely that the effects of thermonuclear dust clouds on the radiation income of Europe will be difficult to detect and probably impossible to assess with any degree of confidence. So far, there has been no indication of any reduction of solar radiation in the British Isles that can be attributed to pollution arising from thermonuclear explosions.

Whether dust clouds of themselves can cause notable augmentation of precipitation is not easily decided. Orthodox meteorological theory excludes ions and all non-hygroscopic particles as nuclei of condensation because of the high relative humidity required. Although direct evidence is lacking, it is very unlikely that relative humidities greater than a fraction of one per cent supersaturation over a pure water surface are ever encountered in the free atmosphere[6]. Observational material accumulated to date points to sea salt as the principal nucleus of condensation, although the oxides of sulphur and nitrogen may play some part. The evidence is not entirely clear, but it is generally accepted by meteorologists that the air over a maritime country like the British Isles has always a sufficiency of nuclei of condensation of finite size for the formation of rain.

If a drop carries an electrical charge of q e.s.u. on its surface, the equilibrium vapour pressure is given by

$$\rho_w R_w T \ln\left(\frac{e}{e_s}\right) = \frac{2\sigma}{r} - \frac{q^2}{8\pi r^4},$$

where ρ_w is the density of water, R^w is the gas constant per unit mass of water vapour, T is the ambient temperature, e and e_s are the vapour pressure and saturation vapour pressure, respectively, σ is the surface tension and r is the radius of the drop. Johnson[6] states that even in thunderstorms, where the drops carry relatively high charges, the term which represents the effect of the electric charge is of negligible importance in the determination of the rate of growth of the droplet. It has not proved possible to compute a likely value for the charge on a drop encountering the radioactive cloud from a thermonuclear explosion several days, or weeks, after the explosion; but it is clear that unless very high charges are acquired, the rate of growth of droplets in the free atmosphere is not affected. The conclusion is thus that it is exceedingly unlikely that radioactive material, whether from a bomb or an atomic pile, can cause any significant increase in rainfall experienced over a large area. In particular, nothing like the classical cloud-chamber process can be envisaged because of the high degree of supersaturation needed.

The World Meteorological Organization is now endeavouring to collect information from member-nations about atomic explosions and climatic effects. How far this appeal has succeeded is not known, and it may be that in the light of further information some of the arguments given above may need revision. Even so, the present state of meteorological knowledge renders it unlikely that a firm conclusion can be reached; but so far the available evidence points to the conclusion that recent thermonuclear trials cannot be held responsible for any world-wide extremes of weather encountered in 1954.

[1] Brunt, D., *Phil. Mag.* (Feb. 1926).
[2] Shaw, W. N., "Manual of Meteorology", **2**, 299.
[3] Brooks, C. E. P., and Hunt, T. M., *Meteor. Mag.*, **64** (1929).
[4] Shaw, W. N., "Manual of Meteorology", **3**, 128.
[5] Brooks, C. E. P., "Climate through the Ages" (1949).
[6] Johnson, J. C., "Physical Meteorology" (1954).

ORIGIN AND AGE OF METEORITES

By Prof. HAROLD C. UREY, For.Mem.R.S.

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BOTH privately and publicly (meeting of the American Association for the Advancement of Science, December 1953, and the Rome meeting of the International Union of Geodesy and Geophysics, September 1954) I have expressed the view that the ages of iron meteorites determined by the helium method are meaningless. Paneth and his collaborators[1] have developed most elaborate and careful methods for the determination of helium and uranium in iron meteorites. The first results were interpreted on the assumption that all the helium was radiogenic, and widely varying ages were secured. Bauer[2] and Huntley[3] pointed out that the helium might well have been produced by cosmic rays, and Mayne[4] showed that helium-3 was indeed present and hence that the helium was partially non-radiogenic in origin. Then subtraction of the estimated amounts of non-radiogenic helium made possible a corrected estimate of the ages from the remaining radiogenic helium. The ages so secured were small, namely, of the order of 10^8 years or less.

Uranium and thorium are exceedingly electropositive elements and they should not be present in the iron meteorites at all, assuming that Goldschmidt's theory for the distribution of elements between the silicate, troilite and metallic phases is correct. The standard free-energy changes for the two reactions:

$$UO_2 + 2Fe = U + 2FeO$$

$$ThO_2 + 2Fe = Th + 2FeO$$

are 126·4 and 138 kcal. respectively at 2,000° K., which is some 200 deg. above the melting point of the iron–nickel alloy. The activity of the iron in the metal is about unity and that of the iron oxide in a

silicate melt of meteoritic composition is about 0·13. Hence the ratio of uranium concentration in the metal to the uranium oxide concentration in the silicate melt should be

$$\frac{[U]}{[UO_2]} = K\,\frac{[Fe]^2}{[FeO]^2} = 10^{-13\cdot8} \times \frac{1}{0\cdot13^2} = 9\cdot4 \times 10^{-13}$$

The corresponding value for $\frac{[Th]}{[ThO_2]}$ is $3\cdot5 \times 10^{-16}$.

It is obvious that except for small amounts due to occlusion or very slight solubility of oxides in the metal phase, uranium and thorium should be much less abundant in the metal phase than in the silicate phase. It may be that their sulphides might be somewhat more stable and that these elements might be present in the troilite phase. One concludes that any uranium and thorium in the iron meteorites are in the silicate or sulphide inclusions. Hence radiogenic helium might escape from the iron meteorites along the fissures that are always present in these objects.

If the iron meteorites were formed by a collision between two asteroids some 10^8 or so years ago, it might be assumed that in the collision which broke up the asteroids the iron melted and the radiogenic and cosmic ray helium formed up to that time was lost. Then the calculations on the ages from the cosmic and radiogenic helium could reasonably be made. But how could the Widmanstätten figures form, since the iron meteorites would cool rapidly and become ordinary iron–nickel steel? This series of events must be rejected because of this difficulty. Another supposition would be that in the collision the irons were not heated to high temperatures and thus retained their Widmanstätten figures, but that the radiogenic helium formed previously and after the time of break-up leaked from the meteorite because it was formed in the occlusions. Since we do not know what fraction of the radiogenic helium was lost, we cannot calculate the age. Paneth *et al.* suggest that the iron meteorites have lost their helium as they passed near the sun. This means that a particular meteorite had an orbit passing near the sun until a time equal to the age which they calculate. Then some close approach to one of the planets perturbed the orbit until the meteorite did not pass near enough to the sun to lose its helium. The Widmanstätten figures were presumably formed during the time of near approach to the sun, or these figures acquired in some earlier process were not destroyed during this time. Then the age records the time since the perturbation occurred. It seems possible that such a series of events occurred in a few cases; but it is most improbable that it occurred in every instance, and thus for most of the meteorites the two alternate courses of events or others must be assumed. While the excellent studies of Paneth and his co-workers are most interesting because of the facts which they present about the formation of meteorites and the effects of cosmic rays, I believe that it is very difficult to decide what event or events were recorded by the helium, uranium and thorium abundances.

At the December 1953 meeting of the American Association for the Advancement of Science, Dr. H. Craig pointed out that the iron meteorites form three rough groups on the basis of nickel content, and that two of these can be correlated with the two prominent groups of chondrites on the basis of equality of nickel content between the irons and the metal phase of the chondrites[4]. Also, plessite, kamacite and tænite, the iron–nickel alloys forming the Widmanstätten figures in iron meteorites, are found in chondritic meteorites[5]. It seems likely that the differentiation of the iron and stone meteorites occurred at the same time and in some closely related processes[6]. At least some metallic iron containing both kamacite and tænite and some crystalline silicate such as that of the achondrites was formed, presumably by melting and crystallization processes prior to the agglomeration of the chondrites. Many studies of these objects show that they have been formed by the agglomeration of fragments of silicates, drops of molten silicate glasses which have been only partly crystallized, and bits of iron–nickel alloys of the plessite, kamacite and tænite varieties. The bent bits of iron, broken crystals and the chondrules which were once molten drops indicate that the process was one of considerable violence, certainly sufficiently so to remove radiogenic argon from the potassium-containing minerals, which are generally among those of lowest melting points.

Recently, Wasserburg and Hayden[7] have shown by the potassium-40/argon-40 method that the ages of two chondrites, Forest City and Beardsley, are $4\cdot6$ and $4\cdot8 \times 10^9$ years respectively. These are the times since the radiogenic argon was removed from these objects, and they have not been melted or heated to temperatures of, say, about 1,000° C. during the past $4\cdot5$–5×10^9 years. The time of formation of these objects was that of the origin of the solar system or earlier. Such ages depend critically on the potassium and argon analyses, which were made by isotope dilution methods at the University of Chicago and the Argonne National Laboratory under the supervision of Dr. M. Inghram and myself. The potassium analysis was checked by another method developed by Dr. G. Edwards and me[8]. These latter analyses show that the chondrites have a remarkably constant amount of potassium near 0·088 per cent. Potassium-40/argon-40 ages of two chondrites have been reported by Gerling and Pavlova[9]. These are given as 3×10^9 years. Their analyses for potassium are 0·18 and 0·17 per cent, twice the average of Edwards's and Urey's analyses and much higher than their maximum value of 0·1024 per cent for the Beardsley meteorite. Whether the difference in ages is real, or due to errors in potassium analyses, or to loss of argon by heating during geological time is difficult to say, though I suspect that these chondrites, like the others, have smaller amounts of potassium than those reported, and hence their ages may indeed fall in the $4\cdot5$–5×10^9 year-range. Patterson and Hayden[10] have found evidence from the ratio of lead-206 to lead-207 in the stones and irons for similar ages, and this means that the lead, which is chalcophile and is in the iron sulphide phase, and uranium and thorium, which are in the silicate phase, have not been separated by melting in this length of time. Since the fragmentation process which formed the chondrites was very energetic, as shown by the evidence that the chondrules were melted, argon must have been lost during the process. Hence this process occurred before the time of the recorded ages.

But the agglomeration into the solid bodies of the chondrites also took place at this time. Any bits of iron, broken crystals and chondrules moving in space near the asteroid belt would have been drawn to the sun in a short period of time by the Poynting–Robertson effect[11] and thus would not have fallen on

the larger asteroids, for example, except for a limited period of time. Much of the differentiation of the meteorites by melting, crystallization, fragmentation and agglomeration took place during the formation of the solar system and not since then, and especially not in the past 10^8 years.

Wahl[12] has suggested that the black chondrites are white chondrites which have been heated above the melting point of iron sulphide ($\sim 1{,}200°$ C.). The black veins of some chondrites have the same chemical composition as the lighter material adjacent to them and thus seem to have been heated by a slip process during the supposed asteroidal collision which produced them. It will be interesting to study the ages of these objects as well as those of the achondrites and stony irons by the potassium-40/argon-40 method as a means of determining the times of these heating processes. Some time ago, Prof. W. Wahl showed me a beautiful series of chondrites ranging from the very loose structure of Bjurböle type through the white and grey chondrites to the black chondrites, indicating different degrees of heating. Also the calcium-poor achondrites, which Urey and Craig suggested may be melted chondrites, show evidence of heating. It will be interesting to secure ages of these objects as a means of estimating the times of these heating processes. One hint in regard to the results to be expected comes from Wahl's[13] study of the polymict stone meteorites. Thus black chondritic material with small enclosures of white chondritic material is enclosed in grey chondrite in the Hainaut meteorite. Other examples are given by Wahl. It seems most likely that all heating except that due to collision processes occurred before the conglomerates of the chondrites were produced. But regardless of the results of such experiments, the results obtained by Wasserburg and Hayden show that the principal differentiations occurred during, or perhaps even prior to, the formation of the solar system.

Kuiper[14] suggested that the melting processes which obviously have occurred in meteoritic material were produced by radioactive heating during the first part of geological time after the planets were formed. This seems not to be the case unless the solar system was formed longer than $4{\cdot}5 \times 10^9$ years ago. The exact time required for melting is in doubt, because of current uncertainties in regard to the cosmic abundances of uranium, thorium and potassium. Hence the course of events on this assumption would be: an accumulation at low temperature of substantial bodies of low conductivity, followed by a long period ($\sim 10^9$ years perhaps) during which they were heated by radioactive heating until they melted, and then an active brecciation by processes incidental to the formation of the solar system some $4{\cdot}5\text{–}5 \times 10^9$ years ago, which produced the chondrites, and finally no heating processes since then. This means that these asteroidal objects and the sun presumably must have been formed at the same time, that is, before the universe is currently assumed to have originated, some $5{\cdot}0 \times 10^9$ years ago—a surprising conclusion for a star of Population I. But perhaps, as I have suggested[15], it may be that these objects, which I called planetesimals, antedated the solar system. Or the universe has no age, as the proponents of continuous creation maintain. Or, it may be that the elements were synthesized or their abundances readjusted to some extent during the formation of the sun, and nuclides of shorter half-lives such as chlorine-36 or cæsium-135 heated these objects. In this event objects of considerable size formed very quickly after the origin of these elements. Or other heating processes occurred as I have suggested. But the simplest assumption is that the universe and solar system are older than we have thought, and that Population I stars are indeed old stars and not even only moderately old stars. Of course, simple assumptions are not necessarily true.

In summary, it seems probable to me that at least most of the meteorites, stones, irons and stony irons have not been heated markedly since the solar system was formed some $4{\cdot}5\text{–}5 \times 10^9$ years ago, and that the processes by which they were formed were indeed part of the early history of the solar system. The ages of iron meteorites determined by the helium method are probably in error because of a leak of the radiogenic helium. This helium was produced in silicate or sulphide (?) inclusions, and hence leaked more or less rapidly along fissures which are present in these objects.

[1] Paneth, F. A., *et al.*, *Geochim. et Cosmochim. Acta*, **3**, 257 (1953).
[2] Bauer, C. A., *Phys. Rev.*, **74**, 225, 501 (1948).
[3] Huntley, H. E., *Nature*, **161**, 354 (1948).
[4] Urey, H. C., and Craig, H., *Geochim. et Cosmochim. Acta*, **4**, 36 (1953).
[5] See, for example, the La Lande, New Mexico, chondrite. Beck, C. W., Stevenson, jun., R. G., and LaPaz, L., *Pop. Astro.*, **59**, No. 2, 93 ff. (February 1951).
[6] For a suggested course of events see Urey, H. C., and Craig, H., *Geochim. et Cosmochim. Acta*, **4**, 72 (1953).
[7] Wasserburg, G. J., and Hayden, R. J., *Phys. Rev.* (in the press).
[8] Edwards, G., and Urey, H. C., *Geochim. et Cosmochim. Acta* (in the press).
[9] Gerling, E. K., and Pavlova, T. G., *Doklady Akademii Nauk, U.S.S.R.*, **77**, 85 (1951).
[10] Patterson, C., and Hayden, R., *Phys. Rev.* (in the press).
[11] See Wyatt, jun., S. P., and Whipple, F. L., *Astrophys. J.*, **11**, 134 (1950).
[12] Wahl, W., *Geochim. et Cosmochim. Acta*, **2**, 91 (1952).
[13] Wahl, W., *loc. cit.*, see illustrations on pp. 93 and 94 particularly.
[14] Boston meeting of the Amer. Assoc. Adv. Sci., December 1953.
[15] Urey, H. C., *Astrophys. J.*, Supp. 1, 172 (1954).

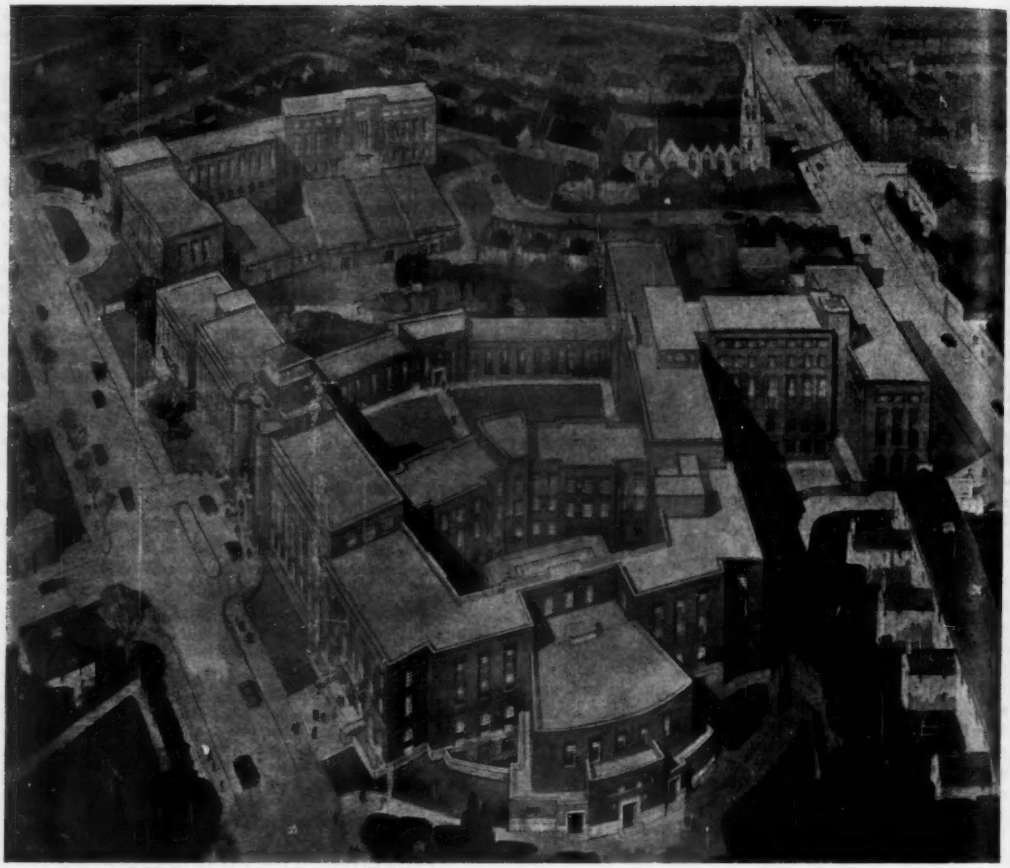
HIGHER TECHNOLOGICAL STUDIES IN NORTHERN IRELAND

By Dr ERIC ASHBY

Vice-Chancellor, The Queen's University, Belfast

IN December 1954 the Royal Assent was given to a Bill in the Northern Ireland Parliament which enables a new experiment to be made in the organization of higher technological education. Hitherto, higher technology has been divided between the Queen's University of Belfast (which concentrated upon civil engineering) and the Belfast College of Technology, which provided, among other subjects, for mechanical, electrical, and aeronautical engineering and chemical technology. The University's Faculty of Applied Science was, at it were, a guest in the laboratories of the College of Technology (an arrangement not unlike that which exists in Manchester), and the staff were officers of the Local Education Authority.

After long and friendly negotiations between the University and the Corporation of Belfast, the conclusion was reached that it would be undesirable in a small Province with a population of 1·3 millions to duplicate facilities for higher technological education in the University and the City. It was agreed, too, that higher technological education, including Higher National Certificate work, should be separated from more modest forms of technological education. The



Architect's sketch (Messrs. Lanchester and Lodge) of the Science and Engineering Buildings now being erected at the Queen's University, Belfast

solution to the problem seemed to be to set up first-rate facilities for teaching and research in higher technology, and to give both the University and the City access to these facilities. This has been accomplished in the following way: (1) Beginning with mechanical and electrical engineering, the University will appoint all teaching staff concerned with work in the Faculty of Applied Science at university salary rates and on the F.S.S.U. (2) Some (but not all) posts on the teaching staff will include obligations to Higher National Certificate students, and the City will contribute to the University part of the salaries of these posts. Other posts may be concerned solely with Higher National Certificate work: these will remain under the local authority. The control of the Faculty of Applied Science will, of course, lie completely with the University.

The Departments of Mechanical and Electrical Engineering, at present located in the College of Technology, will move ultimately to a building (shown at the top left-hand corner of the accompanying architect's sketch) in the new science and engineering site of the Queen's University. The main block of new buildings on this site is at present in construction and will be ready for occupation in 1958–59. The block facing the road on the left is to accommodate civil (and temporarily electrical) engineering; the block facing the road on the right is to accommodate botany and zoology; and the intervening block and two of the three cross-wings are to accommodate chemistry. The third cross-wing (a single-story building) is to accommodate the Aeronautics Department endowed by Messrs. Short Brothers and Harland, together with a hydraulics laboratory. A branch of the University Library, containing sections on engineering, chemistry and the biological sciences, will be accommodated in the building.

These new buildings are less than five minutes walk from the centre of the University, and the Senate has therefore made no provision for meals or student common rooms in the buildings, in the hope that science and technology students would thereby be persuaded to meet students from other faculties, at least at meal times. The size of the buildings is sufficient to accommodate adequately the present numbers of University students: some 380 in science, 150 in first-year medicine and agriculture, and 460 in applied science and technology, together (ultimately and when the second block is complete) with some 500 students taking Higher National Certificate.

CARL FRIEDRICH GAUSS AS A PHYSICIST

By Dr. N. DAVY
University of Nottingham

THE name of Gauss is worthy to stand beside that of Newton and Archimedes. Born on April 20, 1777, the son of a bricklayer at Brunswick, Germany, he early displayed great mathematical ability. In 1807 he became director of the new astronomical observatory at Göttingen, and professor of astronomy in the university there. Working hard and continuously, not seeking new positions, and seldom leaving his observatory, he eventually died there on February 23, 1855. Space will not permit the analysis of many of his 124 memoirs, all significant, catalogued by the Royal Society, and his biography must also be sought elsewhere[1,2]. In the first part of his life, Gauss devoted himself in turn to the theory of numbers, algebra, general analysis, astronomy and geodesy. His mighty works in these subjects were described long ago by able pens[3–5]. The purpose of the present article is to survey briefly Gauss's work in physics.

About the year 1831, when Wilhelm Eduard Weber became professor of physics at Göttingen, Gauss became interested in terrestrial magnetism. The great problem then was—as it still is—to find the source of the earth's permanent magnetic field. Halley (1692), following on the work of Gilbert (1600), had suggested that the field might be ascribed to a set of four magnetic poles. Some meagre data to test this had been accumulated by 1831, when philosophers were measuring, at irregular times and at a few scattered places, the three so-called elements of the terrestrial field. These were the angle of variation, now called declination, the angle of inclination or dip, and the intensity of the field. The venerable Humboldt, both by precept and example, emphasized the need for measuring the third element, as well as the others, with the utmost precision.

Humboldt and Arago were the first to establish magnetic observatories, in buildings free from iron. In 1833 Gauss and Weber constructed an improved observatory of this type at Göttingen, in which the declination apparatus, unifilar and bifilar magnetometers were all invented by themselves. This observatory and the procedure adopted therein soon became a model for others throughout the world. Gauss's first memoir on terrestrial magnetism was written in Latin, in the grand classical manner of Gilbert and Newton. It was called "Intensitas vis magneticae terrestris ad mensuram absolutam revocata" (1832). Improving on the work of Poisson (1828), he here introduced his method of measuring H, the horizontal component of the earth's field. The same paper also contained Gauss's method of proving experimentally the law of inverse squares, which at first assumes a law of the inverse nth power and goes on to show that n is equal to two. A third manifestation of genius, in the same memoir, was the introduction of absolute units into physics. As measured at Göttingen, at 5 p.m. on September 18, 1832, the value of H was found to be 1·782088, which Gauss only claimed to be accurate as far as 1·7821, in terms of the millimetre, the milligram and the second, as units of length, mass and time. In the middle of such researches, Gauss and Weber (1833) constructed what has been called the first practical electro-magnetic telegraph, using wires connecting the astronomical and magnetic observatories at Göttingen. The distance was about 3,000 ft.

The name 'gauss' was first fittingly bestowed on the unit of magnetic intensity. More recently, it has been replaced in that connexion by the term 'oersted', and the gauss is now the unit of magnetic induction; but numbers of physicists and engineers, reluctant to change with the fashion, persist, in private, in calling the unit of magnetic intensity a gauss, a name for which they have acquired a certain affection.

To procure accurate and extensive data so that a proper theory of terrestrial magnetism could be developed, Gauss, from 1831 onwards, organized a Magnetic Union of observatories. At places throughout Europe, daily measurements of the three elements were made at the same moments and at the same regular intervals. By the efforts of Sabine and Lloyd, and following a letter by Humboldt (1836) to the Duke of Sussex, then president of the Royal Society, the British Government was persuaded to assist, very heartily and effectually, by erecting magnetic observatories at home and in the Colonies. A special expedition of two ships, the *Erebus* of 370 tons and the *Terror* of 340 tons, under Ross, was sent to the Antarctic in 1839, with the primary object of making magnetic measurements in a region concerning which earlier information was very scanty. Other governments, especially that of Russia, gave their support, and in 1840 it was reported that thirty-two new observatories were established, or nearly so. For the sake of comparison it may be noted that in 1940 about seventy-five magnetic observatories were in operation, some in polar regions, not only measuring the elements at regular intervals, but also making continuous recordings of their fluctuations, now called 'variations'.

We now turn to Gauss's theoretical work. He had no theory of magnetism itself. He was concerned with terrestrial magnetism, the phenomena of which may be divided into the permanent main field and its variations, daily, monthly, annual, secular and non-recurrent (magnetic storms).

Neglecting the variations, in the memoir "Allgemeine Theorie des Erdmagnetismus" (1838), Gauss's purpose was to discover the law or formula which accounts accurately for the permanent magnetic potential and field everywhere on the earth's surface. The theoretical tools were at hand, thanks to Laplace and Legendre. Gauss assumed that the potential, at any point on the earth's surface, was a solution of Laplace's equation. He assumed also that the field was wholly due to sources inside the earth, and that the potential V could be written as the convergent series:

$$V = S_1/r^2 + S_2/r^3 + S_3/r^4 + S_4/r^5 + \ldots$$

terms after the fourth being negligible. Here r was the distance of the point from the centre of the earth, and S_1, S_2, S_3, S_4 were surface harmonics, functions of the latitude and longitude of the point. The first term could be regarded as due to a uniform magnetization of the earth, or to a small magnet placed at the centre. The other terms could not be interpreted physically. S_1, S_2, S_3 and S_4 were expressed in terms of twenty-four constants and trigonometrical functions of the latitude and longitude. This could not be done accurately with the older observations, and Gauss acknowledged that it was the publication in

1838 of Sabine's tables and chart of lines of equal total intensity, in the seventh report of the British Association, which inspired him to complete the laborious task. He also used the inclination (dip) chart by the German, Horner, and the declination chart of Barlow. Gauss then tested his formula by calculating fields at new points, and also the positions of the terrestrial magnetic poles. These last he predicted, in 1838, to be near 73° 35′ N., 95° 39′ W., and 72° 35′ S., 152° 30′ E., respectively, long before Amundsen (1903–6) found the North Pole to be at 71° N., 96° W., and the Discovery expedition (1902–4) found the South Pole at 72° 50′ S., 156° 20′ E. Thus Gauss laid a firm foundation for the theory of terrestrial magnetism on which Schuster, Gunn and others have built. Using the better observations of 1885, Neumayer recalculated the twenty-four constants. Schmidt (1889) found that 1 per cent of the field was due to external sources. Later still, in 1923, Bauer found that 3 per cent was due to a potential arising from external sources, 94 per cent to a potential arising from internal sources, and 3 per cent, of non-potential origin, to electric currents in the atmosphere, but this last result is disputed by some authorities. Chapman has shown that about 72 per cent of the diurnal variation is due to external, and 28 per cent to internal sources. The quality of Gauss's work is indicated by the following comment by Clerk Maxwell: "Gauss, as a member of the German Magnetic Union, brought his powerful intellect to bear on the theory of magnetism, and on the methods of observing it, and he not only greatly added to our knowledge of the theory of attractions, but reconstructed the whole of magnetic science as regards the instruments used, the methods of observation, and the calculation of the results, so that his memoirs on Terrestrial Magnetism may be taken as models of physical research by all those who are engaged in the measurement of the forces in nature".

Maxwell's reference to attractions probably relates to Gauss's memoir, "Allgemeine Lehrsätze in Beziehung auf die im verkehrten Verhältnisse des Quadrats der Entfernung wirkenden Anziehungs- und Abstossungs-kräfte" (1840). These theorems relate to gravitation, electrostatics and magnetism. Among them we find that celebrated theorem, Gauss's theorem *par excellence*, showing that the total normal outward flux of force over a closed surface is 4π times the electric charge or magnetic pole-strength enclosed, or $4\pi G$ times the mass enclosed.

Much of Gauss's work in pure mathematics has contributed, since his time, to advances in electricity and magnetism. For example, in order to calculate the magnetic field of a two-dimensional pole-piece the cross-section of which is a curvilinear triangle, and the sides of which are circular arcs, one must first use Gauss's concept of a conformal transformation to change the edge of the triangle into the real axis of another plane. This is done by the aid of Gauss's hypergeometric equation, which is solved by Gauss's methods.

Turning to optics, we find another manifestation of Gauss's power in the memoir "Dioptrische Untersuchungen" (1840). Here the concept of principal points was introduced, a concept which reduced the laborious mathematics of thick lenses and sets of coaxial lenses almost to the easy algebra of single thin lenses. Gauss's ideas were extended in 1845 by Listing, who discovered nodal points. Along with this may be mentioned, as a bagatelle of genius, Gauss's optical invention called a heliotrope (1821), based on the law of reflexion of light by plane mirrors, and useful in geodetic work for sending signals of sunlight to distant points.

Like Newton, Gauss wrote a "Principia", not a bound book, but a memoir called "Principia generalia Theoriae Figurae Fluidorum". To Gauss this was just a trifle, but it alone would have made the name of a lesser man. The principle of virtual work and the calculus of variations were applied to a liquid standing in a capillary tube. The differential equation of the free surface and Young's equation relating to angles of contact were deduced in an elegant manner, free from a defect which vitiated Laplace's treatment of the same topic.

Gauss never rushed into publication. As the years passed, he became more and more averse to it or indifferent to priority. Von Waltershausen tells us that in 1831 Gauss suddenly took up crystallography, quickly mastered it in a few weeks and as suddenly relinquished it. His unpublished note-book shows that he had largely forestalled the later work of Miller.

There is no space to relate all Gauss's personal peculiarities, his virtues and failings, his literary style, his veto on the taking of notes of his lectures by his students, his adverse opinion on Abel's first great paper, and so forth. We trust that enough evidence has been adduced to show that, in both theoretical and experimental physics, Gauss was as great a master as in mathematics and astronomy, and that, as Johnson said of Goldsmith, he touched nothing which he did not adorn.

[1] von Waltershausen, W. Sartorius, "Gauss zum Gedächtniss" (Leipzig, 1856).
[2] Tucker, R., *Nature*, **15**, 533 (April 19, 1877).
[3] Prasad, G., "Some Great Mathematicians of the Nineteenth Century", 3 vols. (Benares, 1933); see vol. 1, pp. 1–67.
[4] Bell, E. T., "Men of Mathematics", pp. 250–305 (London, 1937).
[5] *Proc. Roy. Soc.*, **7**, 589 (1856).

OBITUARIES

Prof. G. V. Anrep, F.R.S.

Prof. Gleb Vasilievitch Anrep, who died in Cairo on January 9, was one of the outstanding physiologists of his generation. He was born in St. Petersburg in 1891, the son of Basil Anrep, professor of pharmacology in the Military Medical Academy, who discovered the local anæsthetic action of cocaine, and who was of Swedish extraction. Gleb Anrep studied at the Military Medical Academy, where he came under the compelling influence of I. P. Pavlov, commencing research work on the conditioned reflexes while still a student. He was not yet qualified when 'Ivan Petrovitch' sent him in the vacation of 1912 to visit Starling, in order to demonstrate to him the effect of vagus stimulation on the secretion of pancreatic juice, and to acquire the method of preparing pancreatic secretin. He already spoke tolerable English, and soon became fluent during that and two similar visits in the next two years, when he worked under Starling at University College, London. The third visit was curtailed by the outbreak of war in 1914, when he returned to Russia, completed his qualifications, and joined the Army, in which he served until 1917 as a medical officer. He then returned to Petrograd, studied at the Institute of Experimental Medicine, and took his M.D. Being opposed to the Revolutionary Government, he joined the anti-

Bolshevik forces of General Denekin in 1918, remaining with them until their defeat, after which, with the help of Starling, he came to England, and worked as a lecturer at University College until 1926, taking a D.Sc. He became naturalized in 1925, and was made a Fellow of University College in 1928.

In 1926 he moved to Cambridge, as lecturer in physiology, was awarded an M.A., and in 1928 was elected a Fellow of the Royal Society.

In 1931 he accepted the chair of physiology at the Fuad I University, Cairo, in succession to Prof. W. H. Wilson, and remained there until a short time before his death.

Anrep was an outstanding experimental physiologist of the classical type, imbibing his inspiration, through Pavlov and Starling, largely from the German school of Ludwig and his contemporaries. His first loyalty was to 'Ivan Petrovitch', whom he revered and imitated largely, and to the land of his birth, the exile from which he greatly deplored. His second loyalty was to Starling, and to England, to both of which he owed so much. Perhaps a third was to Egypt, the deserts of which he explored with characteristic intrepidity and enthusiasm, having acquired a good knowledge of Arabic, and always having had a taste for adventure.

His physiological work fell into two main categories: in Russia, on the conditioned reflexes; and in England and Egypt, on circulatory problems. His first paper in the *Journal of Physiology*, in 1912, showed that the rise of blood pressure which followed when the splanchnic nerve was stimulated was in part due to the release of adrenaline. He was made a member of the Physiological Society in 1913, and contributed many papers to that and other journals, on such subjects as the coronary circulation, pancreatic and salivary secretion, the pulmonary circulation, cardiac reflexes, tissue histamine, and the peripheral circulation.

All his work was technically first-class; he had a terrifying capacity for work, was a quick and skilful, but rather temperamental, operator, and had a great knowledge of the literature of his subject.

As a person, Anrep was engaging, buoyant, dynamic, with quick enthusiasms and Slav introspectiveness; and, on occasion, as when an experiment failed, he was capable of acute self-depreciation. He had great gifts as a raconteur and as a lecturer of an unusual type. He was a keen collector of apparatus and of postage stamps.

He had one son by his first wife, Olga; by subsequent marriages no issue. C. Lovatt Evans

Mr. A. S. Ramsey

Arthur Stanley Ramsey, senior Fellow of Magdalene College, Cambridge, died at Cambridge on December 31.

He was born at Hackney in 1867, the eldest son of the Rev. Averell Ramsey, a well-known Congregational minister. He was educated at Batley Grammar School and Magdalene College, Cambridge, where he graduated fifth wrangler in 1889. After seven years as mathematics master at Fettes College, he returned to Magdalene in 1897 as Fellow and lecturer in mathematics, and held the latter post until his retirement from active teaching in 1934. When the office of University lecturer was instituted in 1926, Ramsey was one of the first to be appointed, and he continued in office until his retirement under the age limit in 1932.

Ramsey would have been the first to disclaim originality in his contributions to mathematics. His great gift was as a teacher, particularly of applied mathematics, and he had an especial understanding of the needs of the average student. He soon realized that there was a great lack of systematic text-books adapted to the course of study, and he set himself with indefatigable industry to fill this gap. In the course of years a truly remarkable series of text-books flowed from his pen. His published works are: "Modern Plane Geometry" (Richardson and Ramsey); "Hydromechanics" (Besant and Ramsey); "Hydrodynamics"; "Elementary Geometrical Optics"; "Dynamics"; "Statics"; "Hydrostatics"; "Electricity and Magnetism"; and "Introduction to Newtonian Attraction". All these books are marked by clear thinking, orderly presentation and a wealth of illustrative examples, and most of them, despite great developments in mathematical theory and method, have maintained a steady and deserved popularity. His lectures were equally clear and systematic, and, in private teaching, there were few questions to which he would not at once produce the answer from among his carefully filed manuscript notes.

In addition to his mathematical work, Ramsey took a very active part in college and university administration. He was successively bursar, tutor and president (that is, vice-master) of Magdalene, and he was a member of the Financial Board of the University of Cambridge for more than twenty years. He had a special interest in religious matters and particularly in the affairs of the Congregational Churches. He was for many years a member of the Council of the Congregational Union of England and Wales, and gave very valuable help to Cheshunt College, Cambridge, as a governor and for nine years as chairman of the governors.

Ramsey was a man of uncompromising integrity, and he was possessed by a tremendous sense of duty. Though he could be formidable indeed in his condemnation of the culpably second-rate, kindliness was never far absent, and in his later years it was his dominant characteristic. In his retirement he could be relied upon to delight his listeners with a seemingly inexhaustible fund of reminiscence, told with inimitable humour. He made a lasting impact upon the life of his College, and both there and elsewhere he will long be remembered as a teacher and as a wise friend. His private life was clouded by two great tragedies, stoically endured. His wife, whom he had married in 1902, lost her life in a motor-car accident in 1927, and three years later came the lamentably early death of his elder son, the brilliant F. P. Ramsey, Fellow of King's and author of "Foundations of Mathematics". He is survived by his younger son, A. M. Ramsey, Bishop of Durham, and by two daughters. D. W. Babbage

Mr. Edwin Grey

One of the last links with the Rothamsted of Lawes and Gilbert's time was broken when Edwin Grey died on January 30 at the age of ninety-five. Young Ted Grey went to the Rothamsted Laboratories in 1872 when he was thirteen years old, and with other boys was trained to carry out the botanical analysis of the hays from the Park Grass plots. He was soon marked out as a careful and reliable worker, and as time went on he took part in the classical experiments on soil fertility and animal feeding of

the second half of Gilbert's reign. For many years Grey was field superintendent in charge of the famous field plots, and never were they better cared for.

Outside his work Grey entered into the social life of the village and Laboratories with great zest, and his unusually clear memory of scenes and dialogue enabled him to record, in his later years, the human story of the Laboratory and its surroundings in two most readable books. One of these, "Reminiscences of the Rothamsted Laboratories, Staff, and Experimental Fields", gives a striking and vivid picture of the original Rothamsted and its great and also its humbler personalities. The other, "Cottage Life in a Hertfordshire Village", portrays in almost photographic detail the daily lives and customs of a small rural community in the last quarter of the nineteenth century.

On his retirement in 1922 after fifty years service, Edwin Grey was presented with an address bearing many of the best known names in agriculture. He maintained his interest in Rothamsted affairs for the rest of his long life. Seldom did one visit him without coming away with some interesting sidelight on the Rothamsted story. He was the last survivor of the old order.

H. V. Garner

NEWS and VIEWS

University College of Rhodesia and Nyasaland

The announcement was made on February 15 that H.M. the Queen has, by order in Council dated February 10, approved a grant of a Royal Charter to the University College of Rhodesia and Nyasaland. The Federal Prime Minister, the Right Honourable Sir Godfrey Huggins, was present at the Council. Furthermore, H.M. Queen Elizabeth, the Queen Mother, has accepted the office of president of the College. As we recorded more than eighteen months ago (*Nature*, **172**, 1 ; 1953), the Carr-Saunders Commission on Higher Education for Africans in Central Africa recommended that the College in which it was interested should be granted complete autonomy and that it should be established by Royal Charter. The news that this has now been done will be pleasing to all who wish well of the experiment now being made in higher education in Central Africa. Reference has been made to this experiment in these columns from time to time (see *Nature*, January 29, p. 181), and the granting of a Royal Charter to the new university institution is indeed welcome. The news that Queen Elizabeth, the Queen Mother, who laid the foundation stone of the College during her visit to Central Africa in 1953, has agreed to become the first president of the College will also be received with pleasure. It is one more indication of the serious interest which the Royal Family takes in university education.

University College of the West Indies

The Jamaica Sugar Manufacturers' Association is to make a contribution to the funds of the University College of the West Indies in response to an appeal made by the Chancellor, Princess Alice, Countess of Athlone. The gift will take the form of 8*d*. a ton on all 'quota sugar' sold during the next seven years. Over this period, the contribution is expected to amount to £75,000. Caroni Ltd., Trinidad, the British Guiana sugar producers and the West India Sugar Company are also to respond to the appeal.

International Conference on the Peaceful Uses of Atomic Energy

Dr. H. J. Bhabha, director of the Tata Institute of Fundamental Research, Bombay, and chairman of the Indian Atomic Energy Commission, will be president of the United Nations Conference on the peaceful uses of atomic energy which opens in Geneva on August 8. Prof. Walter G. Whitman, head of the Department of Chemical Engineering at the Massachusetts Institute of Technology, will be secretary-general of the conference. In this capacity, Prof. Whitman will serve as an officer of the U.N. Secretariat, and he will be assisted by a three-man U.N. working party consisting of Ralph J. Bunche and Ilya S. Tchernychev (U.N. Under-Secretaries), and Dr. Gunnar Randers (special consultant to the Secretary-General, Dag Hammarskjold, in matters relating to the conference). Eighty-four countries have been invited to attend the conference. Mr. Hammarskjold said the nominations were made in accordance with the views of the seven-nation advisory committee drawing up plans for the conference. He will appoint six vice-presidents from nominees to be designated by Brazil, Canada, France, the Soviet Union, the United Kingdom and the United States, which with India constitute the advisory committee ; India is, of course, providing the president. There will also be a chairman and a *rapporteur* for each of the sections into which the conference will be divided for working purposes. These officers will be appointed by the Secretary-General before the conference opens. They will be selected from scientists eminent in the relevant fields, and equitable geographical distribution will be taken into account

After a preliminary address by Dr. Bhabha, the conference will open by considering the world's estimated power requirements in some fifty years time, in order to set the stage for discussion of the effect of nuclear energy on the world power problem. The agenda is divided into the following main subjects : need for a new power source ; the role of nuclear energy ; the building of a nuclear energy enterprise ; health and safety aspects of nuclear energy ; production and use of isotopes ; problems relating to large quantities of radioactive substances. These will be considered in plenary session. In addition, section meetings will be held on such topics as reactors, biological and medical questions, and the application of isotopes to research and industrial problems. All subjects must be dealt with and presented only from the scientific and technical points of view. Papers must reach the Secretary-General not later than July 1 ; their titles, accompanied by an abstract not exceeding 500 words, should be submitted by May 15. Each country and specialized agency attending may send up to five representatives including, to the extent possible, individual experts competent in the atomic energy field ; they may be accompanied by as many advisers as necessary. All meetings will be held in public, and will be interpreted in four languages,

English, French, Russian and Spanish. As the conference will last only twelve working days, there will not be time for all papers to be presented orally. The choice of those to be read to the conference, in full or in part, will be made by a panel of qualified scientists to be designated by Mr. Hammarskjold on the advice of the advisory committee. Papers which are not presented orally will still be considered part of the conference, and will be included in its published proceedings.

Public School and Grammar School Boys for Industry

FOLLOWING the pamphlets recently issued on careers for university graduates in industry and directing the attention of industry in Britain to the growing importance of the universities as a recruiting ground for the ablest talent in each generation of school-leavers (see also p. 313), the Education Committee of the Federation of British Industries has now prepared a further pamphlet on the recruitment and training of the public school and grammar school boys in industry (pp. 12. Fed. of British Industries, London, 1954. 1*s*.). The pamphlet suggests that industry is in danger of neglecting an important source of managerial talent, and it makes detailed proposals as to the way in which firms able to offer posts suitable for public school and grammar school boys could summarize information regarding such posts and training on a standard index card for distribution to the appropriate schools. This distribution could be made direct to any schools with which the firm has already established contact, or with the co-operation of the Central Youth Employment Executive and the Public Schools Appointments Bureau.

The pamphlet points out that educational changes since the Second World War have led to many more grammar school boys in Britain remaining at school until they are seventeen or eighteen, while to-day 17 per cent of the total number of boys in the secondary schools are educated in grammar schools compared with 11·5 per cent in 1938. The selection procedure appears to be reasonably effective and, broadly speaking, the best intellectual talent in the secondary schools of England and Wales is to be found in the grammar schools, and, in Scotland, in the senior secondary school. Accordingly, industry can no longer count on recruiting from the elementary school leavers a sufficient number of those possessing the intellectual capacity and character demanded of foremen, departmental superintendents, managers or directors. Since at present 18 per cent of grammar school boys leave at 15, 48 per cent at 16, and 34 per cent between 17 and 19, there is still a large proportion of them, and of public school boys, available for recruitment at an age when industry is in direct competition with the Civil Service and other professions. Schoolmasters, in general, are probably less familiar with the prospects in industry, and the pamphlet is designed to dispel lack of knowledge which is leading industry to misuse valuable recruits.

Metallurgical Developments at Swansea

METALLURGY is an applied science, and in the words of Prof. R. Mehl is "a composite of learning and of abilities-to-do". As a university subject, like medicine, it is based on the pure sciences, which form the main part of the curriculum in the intermediate and subsidiary years. The reduction of metal from ore has been receiving a great deal of scientific study; but it is felt that the manipulation and utilization of the reduced metal itself requires increased attention' and in the widest field. Metallic parts for modern structures frequently involve expensive engineering operations, but by the co-operation of the metallurgist, the engineer and the physicist, metallurgical short-cuts may be provided. A scientific study of fabrication processes on a suitable scale may cure existing troubles and lead to improved techniques. This involves a type of physical metallurgy which can be called 'fabrication metallurgy'. It would cover welding and joining, precision casting, extrusion, powder metallurgy and mechanical deformation. The Steel Company of Wales and Richard Thomas and Baldwin, Ltd., have together made a munificent gift, totalling £100,000, to the University College of Swansea to develop work along these lines. Certain portions of the existing courses will be amplified, and students may be able to select alternative lines of study in their last year. The introduction of post-graduate courses is being considered. Laboratory extensions are in hand and research fellowships are contemplated. A professor of physical metallurgy will be appointed within the existing Department, to deal with the teaching and research which this development involves.

Charles Blachford Mansfield (1819–55)

A PIONEER in the aniline industry, Charles Blachford Mansfield, died one hundred years ago on February 26, 1855, a martyr to science. He was born at Rowner in Hampshire on May 8, 1819, and was educated at Winchester and Cambridge, where he took his B.A. degree in 1846. At the newly founded Royal College of Chemistry in London he became the favourite pupil of the superintendent, August Wilhelm von Hofmann, under whose direction he found coal-tar naphtha to be an abundant source of benzene. Benzene had lately been found in coal-tar and named by von Hofmann. By freezing a carefully fractioned sample of coal-tar naphtha, Mansfield in 1849 obtained with the aid of simple dephlegmators a pure benzene distilling below 100° C. which was a prerequisite for the aniline industry. In a pamphlet, "Benzol, its Nature and Utility", he mentioned that a peculiarly brilliant light could be produced by charging air with its vapour. During the 1849 cholera epidemic he advocated a pure water supply for Bermondsey and other districts. Interested in aeronautics, he wrote a book on "Aerial Navigation", which contained a number of remarkable forecasts. In his lectures on the chemistry of metals, delivered at the Royal Institution in 1851–52, he attempted a classification of his own devising. In 1852 he visited Paraguay and drew up a scheme for the colonization of the Gran Chaco. He pointed out the wastage of beef and other animal matter, which could be used for making ammonia or saltpetre, and suggested that the vast stores of timber wasted might be turned into huge unsinkable rafts across the Atlantic. Mansfield's chief contribution to theoretical chemistry was his "Theory of Salts", published in 1855. He was engaged in preparing samples of benzene for the Paris Exhibition, when on February 17, 1855, a naphtha-still in his laboratory at St. John's Wood overflowed. Severely burned, he died nine days later at the Middlesex Hospital, at the early age of thirty-six.

Catalogue of Optical Instruments

NEW illustrated editions have recently been issued of Sections *D* and *M* of the "Hilger General Cata-

logue" (obtainable from the Hilger Division, Hilger and Watts, Ltd., 98 St. Pancras Way, London, N.W.1). Section *D* deals with monochromators for ultra-violet, infra-red and visible radiation and with wave-length spectrometers and specialized spectroscopes, and mention is made of a new series of monochromators, now in the final stages of design, which are planned to replace the former Müller–Hilger Uvisor instruments. Section *M* deals with a wide range of apparatus, including refractometers, polarimeters, temperature regulators, strain viewers, and photoelastic and electrophoresis apparatus. Two types of temperature-regulating devices for optical instruments fitted with water jackets are offered. For precise measurements the B.T.L. thermostatic water circulator made by Baird and Tatlock (London), Ltd., and designed in conjunction with the Hilger Division of Hilger and Watts, Ltd., is recommended, and for less critical work the Gallenkamp water heater, which is well suited for the Abbe type of refractometer. Other refractometers described are the Hilger–Chance refractometer for solids and liquids, the Rayleigh interference refractometer for gases or for liquids, and a thin-film ultra-violet refractometer for liquids.

National Institute of Agricultural Botany

The work of the National Institute of Agricultural Botany during the past year is reviewed in its *Journal* (**7**, No. 1; 1954). This number includes an account of the oldest regional trials centre, the Norfolk Agricultural Station, and in various ways indicates the many sides of the Institute's work, including reports of trials, classifications of varieties, methods of assessing premature germination (that is, 'sprouting') in wheat, and a further report from St. Albans on quality of oats. This latter paper describes an interesting investigation into decayed kernels. There is also a full report on the crop conference held in December 1953. The proceedings were of general interest, and the emphasis on quality is of topical importance. It was probably the first occasion when growers' representatives of so many areas have been able to meet millers and bakers, maltsters and brewers, for a full discussion of their different points of view.

Fifteenth International Congress of Zoology, London, 1958

The Fifteenth International Congress of Zoology is to be held during July 16–23, 1958, and will meet in the Imperial College of Science and Technology, London. The president is Sir Gavin de Beer, director of the British Museum (Natural History); secretary-general, Prof. H. R. Hewer (Imperial College, London, S.W.7); assistant secretary-general, Dr. G. E. Newell (Queen Mary College, London, E.1). In preparation for the work on zoological nomenclature by the Congress, arrangements will be made by the International Trust for Zoological Nomenclature in conjunction with the secretariat of the Congress for a colloquium on zoological nomenclature to be held immediately before the Congress, to start on July 7. The task of the colloquium will be to examine in detail the draft text of the *Règles* as amended by the Paris and Copenhagen Congresses, prior to their submission to the Congress for adoption. Formal invitations to attend the Congress will be issued in September 1957. All communications meanwhile should be sent to the Secretary-General at the above address.

Royal Astronomical Society: Officers for 1955–56

The following have been elected officers for 1955–56 of the Royal Astronomical Society: *President*, Sir Harold Jeffreys; *Vice-Presidents*, Dr. J. Jackson, Prof. A. C. B. Lovell, Dr. R. A. Lyttleton (*geophysical secretary*), and Prof. H. H. Plaskett; *Treasurer*, Prof. L. M. Milne-Thomson; *Secretaries*, Prof. C. W. Allen and Dr. A. Hunter; *Foreign Secretary*, Sir Harold Spencer Jones; *Council*, Dr. A. Armitage, Dr. D. E. Blackwell, Prof. H. Bondi, Mrs. E. M. Burbidge, Mr. E. H. Collinson, Prof. V. C. A. Ferraro, Mr. T. Gold, Dr. R. W. B. Pearse, Dr. J. G. Porter, Dr. S. K. Runcorn, Mr. D. H. Sadler and Dr. P. A. Sweet.

Announcements

H.R.H. The Duke of Edinburgh has been elected the first Honorary Fellow of the Pharmaceutical Society of Great Britain.

President's Awards announced on Indian Republic Day (January 26) have been made to Prof. V. R. Khanolkar, director, Indian Cancer Research Institute, Bombay, India, and to Prof. M. S. Thacker, director, Indian Institute of Science, Bangalore, India.

Mr. W. S. Bisat, a well-known civil engineer of Leeds and Fellow of the Royal Society, has been awarded the Liverpool Geological Society Medal in recognition of his work on goniatite faunas and their use in the subdivision of the Carboniferous in the North of England.

Mr. R. H. Gummer, a director of International Combustion, Ltd., and associated companies, has been elected president of the Institute of Fuel, in succession to Dr. W. Idris Jones, director-general of research to the National Coal Board. Mr. Gummer is a founder-member of the Institute, and is well known for engineering activities connected with fuel.

Dr. C. J. Gadd, keeper of Egyptian and Assyrian antiquities at the British Museum, has been appointed to the University of London chair of ancient Semitic languages and civilizations tenable at the School of Oriental and African Studies. The title of reader in agronomy in the University of London has been conferred on Mr. A. G. Davis in respect of the post held by him at Wye College.

The fourteenth International Horticultural Congress will be held at Scheveningen, Holland, during August 29–September 6. Further information can be obtained from the Honorary Secretary, International Horticultural Congress, Ministry of Agriculture, Bezuidenhout 30, The Hague.

The first International Congress on Documentation of Applied Chemistry will be held in London during November 23–25. Further information can be obtained from the Honorary Secretary, International Congress on Documentation of Applied Chemistry, 56 Victoria Street, London, S.W.1.

A conference on "Low Temperature Physics" will be held under the joint auspices of the International Union of Pure and Applied Physics and Commission I of the Institut International du Froid as part of the four-yearly International Congress of Refrigeration which commences at the Sorbonne, Paris, on August 31. The first sessions will be mainly devoted to the applied aspects of low-temperature physics; those concerned mainly with pure physics will begin on September 2. The proceedings will end on September 8. Further information can be obtained from Prof. L. Weil, Institut Fourier, Place du Doyen Gosse, Grenoble, Isère.

EARLY SCHOOL LEAVING

AN inquiry into the factors influencing the age at which children leave school, and the steps desirable to increase the number of those who stay after the age of fifteen, has been completed by the Central Advisory Council for Education (England). The Council's findings and recommendations have been published in a report, "Early Leaving" (H.M.S.O., 1954. 3*s*. 6*d*. net) (see also p. 313).

A comprehensive study was made of the number of leavers at various ages, something of their background, school records, motives and subsequent careers. For this purpose, a 10 per cent sample was taken of maintained and direct-grant grammar schools in England.

The heads of 114 schools completed a questionnaire giving as much information as possible on these lines in respect of each boy and girl who entered school with the intake of September 1946. In addition, evidence was secured from boys and girls themselves, through youth clubs and certain groups of national servicemen.

One of the most important factors influencing the age at which boys and girls leave school was found to be the home background. Professional and managerial families' children accounted for only 15 per cent of the child population, but represented 25 per cent of the grammar school population and 43·7 per cent of the sixth-form complement.

School records of children in different social groups were studied, and it was found that from children of parents in professional or managerial occupations at one extreme to the children of unskilled workers at the other there is a steady and marked decline in performance at the grammar school, in the length of school life, and in academic promise at the time of leaving. This is not a mere development of the better performance at the age of eleven of children in certain groups; it reflects a widespread changing of places in academic order between eleven and sixteen or eighteen years of age.

Shortage of money in itself is a less-common reason for leaving than some others—overcrowding in the home and "different social assumptions" are important considerations. The handicap of adverse home conditions, moreover, tends to increase throughout the school course and falsify many of the predictions made in the process of selection.

To meet the problem raised by unsuitable home conditions, the report recommends investigation and possible help by an appropriate social agency such as the school health service, provision of boarding facilities by local education authorities, and concessions by schools and education authorities, such as keeping the public libraries open until 9 p.m., keeping schools open after normal hours, in country areas the opening of primary school premises in the evening, and more generous assistance to youth clubs which cater especially for grammar school pupils.

Boys tend to stay longer at school than girls and do rather better academically. Evidence confirms the common belief that many parents attach more importance to their sons' education than to that of their daughters.

The Council found that while there has been a continued and marked tendency towards a longer school life since the War, there was a very large number of boys and girls leaving at fifteen who would do well to stay on at school for another year. The value of a school life extending beyond sixteen depends on the character, and especially the intellectual ability, of the particular child.

From the grammar school intake of 1946, in addition to about 10,000 boys and 7,000 girls who took advanced sixth-form courses, there were about 5,000 boys and 5,000 girls who had the capacity to do so if they had stayed longer at school. Of these, about 2,900 boys and 1,300 girls would have been suitable for courses in science or mathematics. There is a great national need for scientists of many kinds; all the scientists of good quality that the schools can produce will be absorbed if the universities and technical colleges can expand their scientific intake. The problem remains of providing the necessary scientific staff for the schools; but if this can be solved, the 4,200 potential scientists out of the additional 10,000 boys and girls who could well take advanced courses should have no difficulty in finding suitable occupations. It is acknowledged that "some of those who have the intellectual capacity for sixth form work may be right to leave without undertaking it"; but if pupils capable of taking advanced courses can be persuaded to stay at school they will be serving both the community and themselves.

The Council recommends that, in drawing up building programmes, local education authorities should estimate generously the need for grammar school places to allow both for an expansion in the size of their intake and also for an increased proportion in the fifth and sixth forms.

The process of selection for secondary education should allow for a small number of grammar school places to be filled at each individual school by alternative methods; more transfers from modern to grammar schools, even after the age of fifteen, should be made.

Local education authorities should review the circumstances in which children leave school early for financial reasons, and adjust their schemes of aid accordingly.

Drastic revision of the less-generous scales, provision of higher grants for older children, generous allowances in respect of further dependent children, and consideration of the use of scales based on net rather than gross income, are the main suggested needs. The Council also believes that the law should be amended to provide for the payment of family allowances for children still at school up to any age. At present such allowances cease when the child reaches the age of sixteen.

A number of recommendations are made for the consideration of employers, trade unions and professional bodies. Many young people, especially boys, leave school early in order to get a job. Conditions of entry to many professions and trades do not encourage a longer school life; craft apprenticeship schemes influence boys to leave school at not later than sixteen. The possibility of reducing the length of craft apprenticeship for boys who have stayed at school for a full five-year course should be considered, and the number of student apprenticeships

increased; terms of admission to the professions should provide a greater incentive to pupils to reach sixth-form standard. In clerical and office careers, there should be a more effective system of grading linked with minimum ages of entry and differential scales of pay.

The report also makes suggestions for administrative action within the schools. These include treating the whole work of the school, including the sixth form, as continuous, and introducing some transition to sixth-form ways of working earlier in the school course; providing more science facilities for girls and experimenting more widely in such courses for boys; providing comparable courses for pupils of similar ability in grammar and modern schools; maintaining regular personal contact with the home and increased co-operation with the Youth Employment Service and employers.

T. H. Hawkins

CENTENARY OF ALUMINIUM

DURING June 1–11, at the Royal Festival Hall, London, the aluminium industry is presenting a Progress Exhibition, not only to mark the centenary of aluminium as a commercial metal but also to demonstrate how the present vast output and unique experience already gained are now being applied to every great industry in increasing measure. It was at the Paris Exposition in 1855 that the French scientist, Prof. St. Claire Deville, who had succeeded in extracting aluminium from clay by a chemical process, exhibited samples of the metal. Aluminium was rated a precious metal, since it cost £60 per pound to produce. The first article to be made of the new metal was a rattle for the child of the Emperor Napoleon III, who ordered aluminium cutlery to replace the gold plate at the Tuileries banquets. An aluminium watch-chain was also presented to the King of Siam, when on a State visit to France. Attracted by its light weight, the Emperor commissioned Deville to produce aluminium on a large scale so that, with its cost reduced, it could be used for equipment for his soldiers. However, only ten tons of aluminium were produced in the whole world in the next ten years, its lowest price being £3 per lb.

In 1886, Charles Martin Hall in the United States and Paul Heroult in France, working independently, simultaneously patented the electrolytic process for extracting aluminium from its oxide. To-day, using basically that same method of extraction, 30,000 tons of pure aluminium are produced in Britain alone, at the great hydro-electric plant in the Scottish Highlands, and world production in 1954 has probably exceeded three million tons and is still increasing. From £144,400 per ton its price is now £165 per ton, and aluminium has the distinction of having increased in price to a less extent than any other important commodity. In 1907 came the discovery by a German scientist, Alfred Wilm, that by alloying small quantities of other metals with aluminium, its strength could be greatly increased. Further research and development in Britain produced a wide range of alloys which made possible the development of the aircraft industry and of the internal combustion engine.

The ten years that have followed the Second World War have been years of remarkable progress when research results have been applied to problems in every industry. First came the aluminium prefabricated house, 70,000 of which were built; to be followed by the adoption of aluminium in permanent building construction. In shipbuilding its success was never more strikingly demonstrated than by the great American liner *United States*, which has more than two thousand tons of aluminium in her superstructure, lifeboats and many fitments; less spectacular applications of aluminium to ships had already become a commonplace in Britain. The world's first aluminium bridges have been built in Britain, and aluminium coaches of London's Underground trains, and aluminium bus bodies on London's streets, provide ample evidence of the faith of the engineer in aluminium.

Its light weight and its resistance to corrosion, symbolized by Gilbert's famous aluminium statue of 'Eros'—now more than sixty years old—have made this the 'Light Metal Age'. If the progress, especially in the past ten years, has been remarkable it is still only a beginning; for the future of aluminium is boundless in its possibilities.

THE VICUNA

IN a recent issue of *Oryx*, Dr. G. Dennler de la Tour has described the characteristics, habitat and behaviour of the vicuna (**11**, No. 6; December 1954).

In form the vicuna resembles the guanaco, but it is smaller and slenderer. Its colour varies from pale fawn, through vermilion and golden to strongly fulvous. The vicuna has no black on its face, as has the guanaco. From the throat to the knees there is a pure white tuft, the belly and inner sides of the limbs being white also. The vicuna stands 28–35 in. high at the shoulder, its average size decreasing from south to north in its South American range. Its wool is shorter but much finer than that of the guanaco and is probably the finest and lightest wool in the world. Vicunas are found in small droves of five to fifteen females led by an adult male which watches over the flock. Young males are expelled from the flock by their mothers when they are eight to ten months old and unite into herds of from twenty to a hundred or more.

The mating season lies between April and June and, as the gestation period is ten months, parturition occurs between January and March. The vicuna almost always produces one offspring; in confinement it does not breed readily.

Vicunas feed on grasses of *Poa*, *Bromus*, *Agrostis*, *Stipa*, and other alpine genera. They drink only every two days and always use the same track to water.

The vicuna, generally speaking, lives at higher altitudes than the guanaco. It enjoys humid meadows which lie adjacent to the eternal-snow summits of the Andes, many of which reach and pass the 6,000 metre mark.

Vicunas occur in the high plateaux of the Andes between 3° S. and 30° S.; that is, in the extreme south of Ecuador, in Peru and Bolivia, in the extreme north of Chile and in north-western Argentina. Their southern limit is in Argentina at about the Agua Negra River, while their Chilean range does not go so far southwards. Where man has advanced with his sheep and goats, alpaca and lama breeding

and his mining, the vicuna has receded to higher altitudes.

The vicuna was plentiful throughout its range in the era of the Inca Imperium. Hunting was only allowed every four or five years under official control, and only adult males were killed, the females being sheared and freed. Under the Spanish Colonial regime, hunting was free and, according to reports, about 80,000 vicunas were killed each year in Peru and northern Chile, leading to a considerable decline in numbers. After liberation from the Spaniards, the natives returned to the earlier practice of shearing and then freeing the animals. Later the decline of the vicuna began again, for the export market demanded vicuna skins, vicuna robes and vicuna wool. The use of firearms destroyed whole flocks, the hunters taking advantage of the females' habit of remaining near the male after he was killed. Thus a whole drove could be slaughtered one after another, and, in this manner, thousands were killed. The wool output of one vicuna gives an average of 500 gm. The superstition that the bezoars (stomach-stones) have a medical and aphrodisiac value may have contributed to the practice of killing the animals, instead of just shearing them.

It is difficult to estimate the number of vicunas living to-day. In Peru the total number in 1940 was calculated at nearly a million; neither from Bolivia, Chile nor Ecuador has it been possible to get reliable data.

Dr. de la Tour doubts whether the total number of vicunas reaches a million, and estimates that it is probably not half a million.

The first protection measures were carried out by the Inca Imperium when hunting was allowed only every four or five years and then under the strictest control. Only the members of the Inca clan were allowed to wear clothes made of vicuna wool or use vicuna robes. After liberation from Spain, Bolivar accorded protection to the vicuna by a decree in 1825. During the present century, Peru issued a decree in 1920 prohibiting the sale of vicuna skins and the making of goods from its wool, and Bolivia prohibited the export of vicuna skins.

Argentina issued a decree in 1926 prohibiting the hunting and exportation of vicunas as well as the transportation and sale of their skin and fur.

There is pressing need for joint action between all five countries to see that existing laws are tightened up and carried out.

A NEW IDENTIFICATION OF THE FLAME SPECTRA OF THE ALKALINE-EARTH METALS

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THE characteristic flame spectra given by the alkaline-earth metals have been used extensively in analysis of these elements for many years, despite doubts as to their nature. In the cases of calcium and strontium they are made up predominantly of two narrow regions for each metal, for calcium at 5560–5470 A. and 6400–6000 A., and for strontium at 6100–6000 A. and 6900–6850 A. They have been ascribed tentatively to gaseous calcium oxide (CaO) and strontium oxide (SrO) respectively by Pearse and Gaydon[1], although other possible ascriptions have been made by King[2], and by Mahanti[3]. Evidence to be given here supports strongly a new hypothesis —that they arise from the radicals CaOH and SrOH, and further that a considerable portion of the radiation in the green given by barium arises from BaOH.

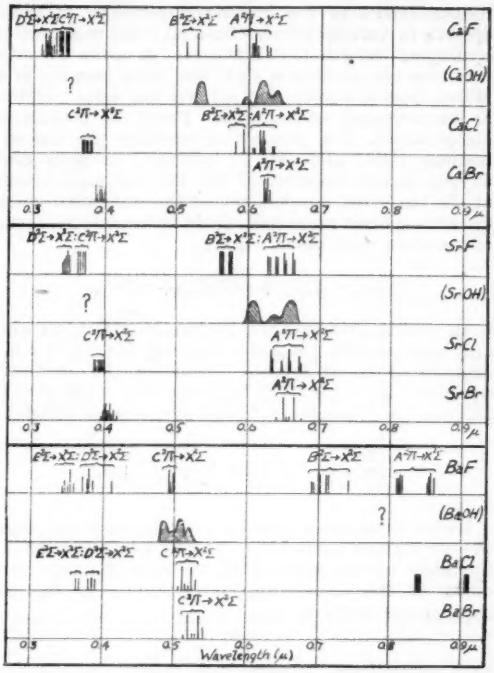

Fig. 1. Diagrammatic spectra of the alkaline-earth halide radicals compared with the intense portions of the flame spectra of the alkaline earths

Fig. 1 shows diagrammatically the main features of the spectra of the halide radicals of the type of CaF, as listed by Pearse and Gaydon, each system falling into a narrow region presumably because of similarity between the potential energy curves of the contributing states. We have inserted between the fluoride and chloride in each case a diagram of the spectrum obtained from these elements in a hydrogen/air flame, using a photoelectric recording device of low resolution in conjunction with a Hilger *E*3 medium quartz spectrograph. The correlation of the two regions of strong emission for calcium and strontium with those of the neighbouring halides ($A^2\Pi \rightarrow X^2\Sigma$ and $B^2\Sigma \rightarrow X^2\Sigma$) is very evident.

In the case of barium, the corresponding transitions are in the infra-red, and have not been considered. Flames containing barium, however, show a zone of diffuse structure, as depicted, near 5000 A., superposed on a background of a much more widespread band system, with more detailed structure. This latter, almost certainly due to barium oxide, has been analysed by Mahanti; but the superposed system shows a correlation with the $C^2\Pi \rightarrow X^2\Sigma$ of the halides (Fig. 1). Since the hydroxyl group in many ways resembles a halogen atom, it is suggested that the spectra noted arise from the radicals CaOH, SrOH and BaOH.

Strong confirmatory evidence is obtained from measurements of the integrated intensity of these spectra in various flames obtained from mixtures of hydrogen, oxygen and nitrogen. A series of such mixtures can be chosen such that after burning in a Mèker type of burner they all give the same (sodium *D* line reversal) temperature. From the preburned compositions, it is possible to calculate the concentrations [OH] and [O] of hydroxyl radicals and oxygen atoms respectively for thermal equilibrium at the measured temperature of the interconal gases (at atmospheric pressure). If M represents an atom of metal in such gases, then :

$$[M_0] = [M] + [MOH] + [MO],$$

if the oxide MO and the hydroxide MOH are the only compounds, $[M_0]$ representing the total concentrations in all forms. Assuming the chemical equilibria $K_1 = [M][O]/[MO]$, and $K_2 = [M][OH]/[MOH]$, $[M_0]$ can be expressed in terms of $[MOH]$:

$$\frac{[M_0]}{[MOH]} = \frac{K_2}{[OH]} + 1 + \frac{K_2[O]}{K_1[OH]}$$

Under these conditions, it is to be expected that the very great majority of the metal is present in the form of the oxide MO, making the first two terms of the above sum negligible[4,5], so that it reduces essentially to :

$$\frac{[M_0]}{[MOH]} \sim \frac{K_2[O]}{K_1[OH]}$$

At a given temperature, for a series of flames with constant $[M_0]$, if the intensity I of a band is proportional to $[MOH]$, then a plot of $1/I$ against the calculated [O]/[OH] should be a straight line passing very nearly through the origin. Such a plot is shown (Fig. 2) for the 5560–5470 A. band from calcium for a series of flames at 2,000° K. Similar sets showing such behaviour have been obtained for the other calcium band and the bands from strontium, also with other series at different temperatures. In the case of barium, finite intercepts are obtained, probably because of the background, for which it is difficult to correct. The flames were all of the shielded type described by James and Sugden[6], and the amount of metal (added as fine sprays of dilute salt solution from an atomizer, the results not depending on the anion) too small to give self-reversal effects. The intensity of the bands, as well as of the resonance line of the metal, varied linearly with the amount added, indicating that they arise from molecules containing only one atom of metal.

The much weaker emission found between 3500 and 4500 A. for calcium and strontium was effectively constant in intensity with a given series of isothermal flame gases, and may be reasonably ascribed to the calcium and strontium oxides, which can be expected to account for well over 90 per cent of the metal. The same is true for the barium flame spectrum outside the narrow limits shown in Fig. 1. This method of using series of isothermal flames is therefore capable of giving diagnostic information about the emitters in such cases as this, and provides a valuable tool for the quantitative study of reactions at high temperatures. The high intensity of the bands attributed to the radicals CaOH, etc., however, makes it very unlikely that they are present in chemical equilibrium, as was assumed in the above scheme, and it is considered probable that they probably arise from collisional processes of metal atoms and OH to give excited molecules which revert to the ground state. This would not affect the form of Fig. 2, except that the slope of the line would no longer be simply related to equilibrium constants.

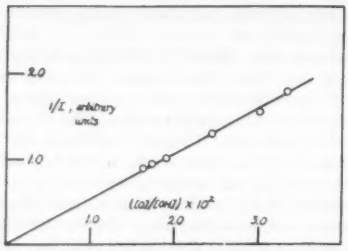

Fig. 2. Plot of reciprocal intensity of the intense band in the calcium flame spectrum at 5560–5470 A. against calculated [O]/[OH] for flames at 2,000° K.

A detailed account of this work will appear elsewhere. One of us (C. G. J.) is grateful to the Department of Scientific and Industrial Research for a maintenance allowance. [Sept. 24.

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ELECTRIFIED DROPLETS FROM THE BURSTING OF BUBBLES AT AN AIR–SEA WATER INTERFACE

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THE bursting of a bubble at an air–sea water interface is an effective mechanism for the production of airborne droplets[1,2]. For small bubbles the large majority of these droplets evolve from the vertical water jet which forms upon collapse of the bubble cavity. This jet, we have found, moves upward at a high velocity and is transformed into five or six droplets. The height of projection of these droplets, a function of bubble size, may reach a maximum of 18 cm. It seems certain that this process significantly contributes to the production of the airborne salt particles present over the oceans.

Early in our study of breaking bubbles[1], it was found that the droplets produced by the vertical jet were electrically charged. With the apparatus schematically shown in Fig. 1, measurements were carried out on the sign and magnitude of this charge as a function of the radius of the droplet. Bubbles were produced at a rate of 3–10 sec.$^{-1}$ by pumping air under 10–30 lb./sq. in. through a finely drawn-out section of glass capillary tubing E. These bubbles burst at the surface of the sea water in the inner container F and ejected electrically charged droplets into the observation region G. This region was sealed

off from the outside air by an open-bottomed rectangular 'Plexiglass' housing *B* which made contact with the sea water in the outer container *D*. It was necessary to use the outer container as a water seal since the distortion of the water surface near the 'Plexiglass' made it impossible to make observations near the water surface. The d.c. power supply *A* was used for producing a uniform, vertical electric field between the brass plate *C* and the earthed surface of the sea water in the inner container *F* by increasing the plate potential to any desired plus or minus value up to a maximum of 12 kV.

The determination of the electrical charge and radius of a droplet ejected by the jet from a bursting bubble was made in the following way. Before the droplet returned to the water surface, the voltage on the plate was adjusted until the droplet was stationary in the electric field. The gravitational force could then be equated to the electric force, giving an equation with two unknowns, the droplet radius and charge. The field-strength was then decreased to allow the droplet to move slowly downward. An equation of motion could then be obtained which, when solved simultaneously with the first equation, gave the droplet radius and charge. A cathetometer was used for observing the droplet and to determine its motion in the electric field. To avoid evaporation of the droplet while under observation, it was necessary that the air and water temperature were essentially the same.

All the results obtained to date, including those shown in Fig. 2, were from bubbles less than about 150 μ in radius, the ejected droplets of which rose less than 20 mm. The weight of salt contained in droplets produced from this range of bubbles is comparable to that found by Woodcock[3] over the oceans. Curve *A* of Fig. 2 is for droplets from bubbles which were allowed to break in the presence of an electric field. In this manner all the droplets originating via the jet mechanism obtained, by electrostatic induction, a charge of opposite sign from that of the plate potential. For a given droplet radius, this charge was substantially the same in the range of fields from 50 to 300 V. cm.$^{-1}$. Curves *B*, *C* and *D* are for the natural charge on the droplets. In these cases the bubbles were allowed to produce droplets before the balancing electric field was applied. It will be noted that the results, unlike those for the induced charges, tend to fall into three

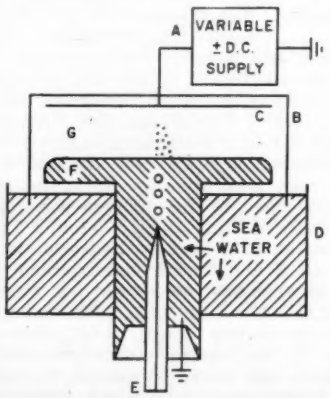

Fig. 1. A schematic view of the apparatus for suspending an electrically charged droplet in a vertical electric field

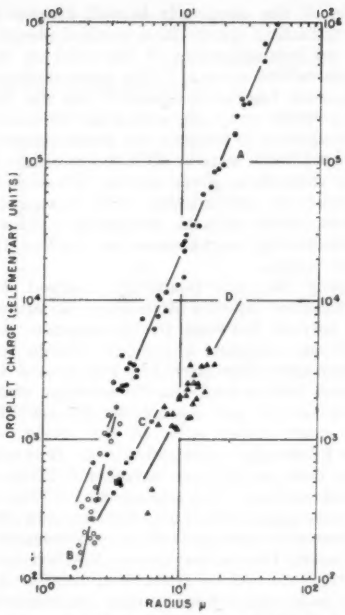

Fig. 2. Natural and induced charge on droplets from bursting bubbles

separate groupings. The first, for droplets less than 3μ radius, indicates an increase of charge nearly proportional to the fifth power of the radius. The second, for droplets between 3 and 6μ in radius, shows approximately a second-power relationship. Other results suggest that this curve is not unique but that a family of curves exists in this region. The third grouping, for droplets greater than 6μ radius, is similar to the second. The maximum charge per unit volume is obtained by droplets of about 3μ radius. At this radius the quantity of charge is nearly identical with that obtained when the bubbles break in the presence of an electric field. To date no explanation has been given for these groupings.

If the maximum height of ejection of droplets is less than about 2 mm., the sign of the charge on all the drops is, almost without exception, positive. For ejection heights of 2–20 mm., which implies larger bubbles, the charge on the droplet ejected to the maximum height is still positive, while the lower droplets may show either sign.

These results lead to some very interesting speculations as to what might happen under various natural conditions. Consider, for example, a thunderstorm passing over the sea with a peak field-strength at the sea surface of 100 V. cm.$^{-1}$. From curve *A* of Fig. 2, one finds that all droplets less than 10 μ in radius originating from the jets of breaking bubbles will be carried upward towards the cloud. One might also wonder about the electric field at the surface of these droplets and its tendency to induce corona discharge. With the equation of curve *A* and Gauss's law, one finds that the field strength *E* (V. cm.$^{-1}$) at the surface of a droplet of radius *R* (microns) is $E = 1{\cdot}24 \times 10^3 R^{0{\cdot}4}$. With *E* varying only as the 0·4 power of the radius, the field-strength at the surface of droplets 3–50μ radius varies only from about 1,900 to 5,900 V. cm.$^{-1}$. These calculations assume that the charge is uniformly distributed over

the surface of the drop. It is well known that a charged conducting sphere in a vertical electric field will have an intensification of the field on the top and bottom of the sphere. This intensification was computed, with Laplace's equation, for the droplets of curve *A* when they are subjected to an electric force just sufficient to balance the gravitational force. The computed fields were in no case more than 15 per cent larger than those given above. These fields are not sufficient for breakdown; but evaporation of the droplets, which almost invariably occurs under natural conditions, might raise the surface field to breakdown values.

It is likely that the positively charged droplets from the smallest bubbles alone carry an appreciable electrical current between the atmosphere and the earth. If one assumes a positive charge totalling 3,000 elementary units carried by the several droplets from a small bubble and, on the average, about one bubble per second per square centimetre breaking over the entire ocean area of the world, then a current of 1,800 amp. will be obtained. It is assumed, of course, that winds and turbulent diffusion will transport these small droplets upward. This current is of the same magnitude but in the opposite direction to the observed current-flow in fair-weather areas over the earth[4]. It is probable that the above estimate of the current carried by these low-mobility droplets is high; but, nevertheless, this mechanism may contribute significantly to the earth's counter or supply current, which at present is attributed to thunderstorms.

Further laboratory- and field-studies should lead to other interesting aspects of this production of charge on droplets from bubbles breaking at the sea surface. This work is being continued, and more detailed publication is planned for the future.

This work was supported by the Office of Naval Research, under contract number *Nonr*-798(00) (*NR*-082-124). [Oct. 6.

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OCCURRENCE OF A NEW BASE IN THE DEOXYRIBONUCLEIC ACID OF A STRAIN OF *BACTERIUM COLI*

By D. B. DUNN and Dr. J. D. SMITH

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THE thymine-requiring strain of *Bacterium coli*, 15 T^-, was first described by Cohen, who has examined in detail several aspects of its physiology[1]. One of the most interesting observations was that, when placed in a synthetic medium lacking thymine, the cells will only survive 15–20 min. before rapidly losing their viability.

We have found that when grown under conditions of thymine deficiency or in the presence of 5-aminouracil or 2-thiothymine, *B. coli* 15 T^- produces a type of deoxyribonucleic acid containing considerable amounts of a new base. This base is also found in small amounts in the deoxyribonucleic acid from cells grown in excess of thymine and also from *B. coli* B.

B. coli 15 T^- was grown on a glucose – ammonium sulphate synthetic medium supplemented with thymine. The addition of the thymine analogues 5-aminouracil (10^{-3} *M*) or 2 thiothymine (2×10^{-3} *M*) to cells at a density of 2×10^8/ml. in medium containing 2·5 μgm./ml. thymine produced inhibition of growth, measured turbidimetrically, beginning after 90 min. (two generation times), and finally resulted in the formation of long bacterial filaments. These effects were completely reversed by the addition of 100 μgm./ml. thymine simultaneously with the inhibitor. Long bacterial filaments were also formed after growth in a thymine-deficient medium (0·2–0·5 μgm./ml.).

Deoxyribonucleic acids were prepared[2] from bacteria grown in the presence of 5-aminouracil, 2-thiothymine, or in low concentrations of thymine, and were hydrolysed in 72 per cent w/w aqueous perchloric acid[3], and the bases separated by two-dimensional paper chromatography in *iso*propanol–water–hydrochloric acid[4] and *iso*propanol–water–ammonia[5]. Unlike the 5-halogenated pyrimidines[6], 5-aminouracil and 2-thiothymine are not incorporated into *B. coli* 15 T^- deoxyribonucleic acids. However, all three nucleic acids gave, in addition to the four usual bases, a fifth ultra-violet-absorbing spot (*X*) which ran with cytosine in *iso*propanol–water–hydrochloric acid and slightly ahead of thymine in *iso*propanol–water–ammonia. *X* was also released from the nucleic acid after hydrolysis for 1 hr. at 55° in *N* hydrochloric acid. In this latter respect it behaved like the purines adenine and guanine.

The ultra-violet absorption maxima and minima of *X* are given in Table 1. Measurement of the change in spectrum over the *p*H range 0–14 indicated the presence of two dissociations with *pK* values of approximately 4 and 10, respectively. The presence of a basic dissociation (*pK* about 4) was shown by paper electrophoresis at *p*H 2·5 and 3·5, when *X* migrated towards the cathode. Its high R_P values in butanol–water–ammonia[7] and *iso*propanol–water–ammonia (Table 1) suggested that *X* possibly contained an alkyl group.

As at first we considered that *X* was likely to be an alkylated pyrimidine bearing a basic group, we compared it with a number of pyrimidines including 5-aminouracil, 5-methylaminouracil, 5-dimethylaminouracil, 5-amino-1-methyluracil, 5-amino-4-methyluracil and 4-amino-5-methyluracil. It soon became apparent that *X* behaved more like a purine than a pyrimidine, and after comparison with several purines (including 2-methyladenine, 6-methylpurine, 8-methylpurine and 6-ethylaminopurine) we found that 6-methylaminopurine[8] was identical with *X* in its ultra-violet absorption spectrum, its chromatographic movement in five different solvents and its electrophoretic mobility at *p*H 2·5 and 3·5 (Table 1). On heating at 120° in 6 *N* hydrochloric acid for 18 hr., both *X* and 6-methylaminopurine were converted into substances which did not absorb ultra-violet light. These on paper chromatography in butanol–water–formic acid, *iso*propanol–water–ammonia or *iso*propanol–water–hydrochloric acid were in each case shown to contain two ninhydrin-reacting substances one of which corresponded to glycine. On hydrolysis with strong hydrochloric acid, the purine ring is known to break down, giving

Table 1. PROPERTIES OF *X*, 6-METHYLAMINOPURINE AND CERTAIN OF THEIR DERIVATIVES

R_F values in	*X*	6-Methyl-aminopurine	Adenine	*X* deoxyriboside	Product formed by the action of nitrous acid on	
					X	6-methyl-aminopurine
*Iso*propanol–water–hydrochloric acid (ref. 4)	0·61	0·61	0·50			
*Iso*propanol–water–ammonia (ref. 5)	0·71	0·71	0·56	0·80		
n-Butanol–water–ammonia (ref. 7)	0·53	0·51	0·29			0·46
n-Butanol–water–formic acid (ref. 7)	0·33	0·33	0·18		0·68	0·68
Ammonium sulphate–sodium acetate–water–*iso*propanol (ref. 5)	0·22	0·24	0·23			
Electrophoretic mobility (cm./hr.) at 20 V./cm.						
*p*H 2·5	10·1	10·4	10·8			
*p*H 3·5	6·7	6·9	9·0	3·1		
Ultra-violet absorption maximum (mμ)						
*p*H 1	267	267	262	265	264*	267*
*p*H 7	267	266	260	266		
*p*H 13	273	273	267	266	274	273
Ultra-violet absorption minimum (mμ)						
*p*H 1	233	232			233	233
*p*H 13	239	239			241	241

* The absorption maximum of this compound is very flat.

glycine, carbon dioxide, carbon monoxide and ammonia[9]. Both *X* and 6-methylaminopurine form insoluble silver and cuprous salts[10], a characteristic of some purines. Treatment with sodium nitrite in acetic acid converts *X* into a substance differing from *X* in its chromatographic behaviour and no longer bearing a positive charge at *p*H 3·5, so it does not migrate on electrophoresis. With this reagent, 6-methylaminopurine gives a product which is presumably 6-methylnitrosaminopurine. This is indistinguishable from the compound formed from *X* in its chromatographic movement in butanol–water–formic acid, its electrophoretic behaviour at *p*H 3·5 and its ultra-violet absorption spectrum (Table 1).

We have also isolated, from 15 T^- deoxyribonucleic acid containing *X*, a substance with the expected properties of the nucleoside of *X*. The nucleic acid was treated with deoxyribonuclease and rattlesnake venom diesterase and 5′-nucleotidase, and the hydrolysate run on paper chromatograms in *iso*propanol–water–ammonia. The deoxyriboside of *X* runs ahead of thymidine and the free base *X*. On paper electrophoresis at *p*H 3·5, it runs more slowly than *X* because of the greater frictional resistance of the larger molecule. At *p*H 1 and 7 its ultra-violet absorption spectrum is similar to that of *X*; but, unlike *X*, the maximum does not shift to the longer wave-lengths at *p*H 13 (Table 1). On treatment with *N* hydrochloric acid at 55° for 1 hr. it is converted to a substance identical with *X*.

A more careful examination of deoxyribonucleic acid from bacteria grown in excess of thymine showed that these contained small amounts of *X* amounting to about 0·4 per cent of the total bases. Quantitative analysis of deoxyribonucleic acids from bacteria grown in the presence of 5-aminouracil, 2-thiothymine, or low concentrations of thymine, showed that, in comparison with nucleic acid from bacteria grown in excess of thymine, the former contained about 20–30 per cent less thymine relative to the other bases, and that this deficiency was almost quantitatively accounted for (on a molar basis) by the amount of *X* present. In these nucleic acids the amount of adenine was also decreased by about 5 per cent.

Table 2. MOLAR PROPORTIONS OF PURINES AND PYRIMIDINES IN DEOXYRIBONUCLEIC ACIDS OF *B. coli* 15 T^- GROWN UNDER DIFFERENT CONDITIONS

Conditions of bacterial growth	Total bases (moles/100 moles)				
	Adenine	Guanine	Cytosine	Thymine	*X*
25 μgm./ml. thymine	23·6	27·5	26·2	22·4	0·4
1·5 μgm./ml. thymine + 10^{-2} *M* 5-amino-uracil	22·3	27·6	26·6	19·1	4·2

We conclude that the new base *X* is 6-methylaminopurine. This has already been shown to replace adenine in the growth of *Lactobacillus casei*[11], and by studying the effect of this substance in the nucleic acid metabolism of *B. coli* 15 T^-, we hope to discover the reason for its appearance in the deoxyribonucleic acids under conditions of thymine deficiency. The fact that 6-methylaminopurine apparently replaces thymine residues in the nucleic acid is extremely difficult to reconcile with the theory of replication proposed by Watson and Crick on the basis of their structure for deoxyribonucleic acid[12] and may mean that the nucleic acid formed is abnormal in other respects. In fact, it was for this reason that we first compared *X* with a number of 4- and 5-substituted pyrimidines in order to eliminate the possibility that it might be a pyrimidine so substituted as to make its deoxyriboside behave like a purine deoxyriboside towards acid hydrolysis.

We wish to thank Dr. S. S. Cohen for the culture of *B. coli* 15 T^-, Dr. D. D. J. Brown and Dr. D. M. Brown for gifts of chemicals and Dr. E. Lester Smith and Dr. A. M. Michelson for chemical advice. One of us (D. B. D.) wishes to thank the Agricultural Research Council for a studentship held during the course of this work.

[Dec. 9.

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LETTERS TO THE EDITORS

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The Endocrine Chain in an Insect

It is now well recognized that growth and moulting in the insect are initiated by a hormone produced in the neurosecretory cells of the brain. This brain factor activates the thoracic gland, which is then believed to secrete the definitive growth and moulting hormone[1]. But the possibility remains that there may be yet further links in the chain of endocrine organs, located in the abdomen.

The œnocytes and the dermal glands have already been excluded[2]; but the pericardial cells and the various types of hæmocytes are obvious possibilities. Blockage of the hæmocytes by the injection of Indian ink into the 4th-stage larva of *Rhodnius* at one day after feeding causes a delay in moulting which may range from one to three or four weeks beyond the normal fourteen days. Blockage of the pericardial cells with trypan blue has no effect—unless sufficient is injected to fill the hæmocytes also. Similar results are obtained with iron saccharate.

These injections no longer cause any great delay if made later than the third day after feeding (Fig. 1): clearly they interfere with the initiation of mitosis in the epidermis (which begins at the fourth or fifth day), not with the ordinary processes of intermediary metabolism. The detailed study of the hæmocytes in *Rhodnius* is not yet complete; but there is already histological evidence of secretory activity becoming evident on the fourth day after feeding.

Butenandt and Karlson[3] have recently succeeded in isolating in crystalline form from the pupæ of the silkworm an active principle which will induce puparium formation in *Calliphora* and which, as proved by Williams[3], will cause renewed development in the diapausing pupa of *Platysamia*. Through the kindness of the German authors I have been able to test the activity of their hormone on *Rhodnius* and have found that 0·5–0·75 μgm. injected into the decapitated 4th-stage larva at twenty-four hours after feeding (weight about 80 mgm.) will induce moulting. In *Rhodnius*, as in *Platysamia*, the hormone is equally effective when injected into the isolated abdomen. This suggests, as Butenandt and Karlson point out, that it is the active principle of the thoracic gland. But in view of the observations reported in this communication, the possibility remains that it may be a product of the hæmocytes. That possibility is favoured by the observation that moulting induced by injection of the hormone is not delayed by blockage of the hæmocytes with Indian ink or iron saccharate.

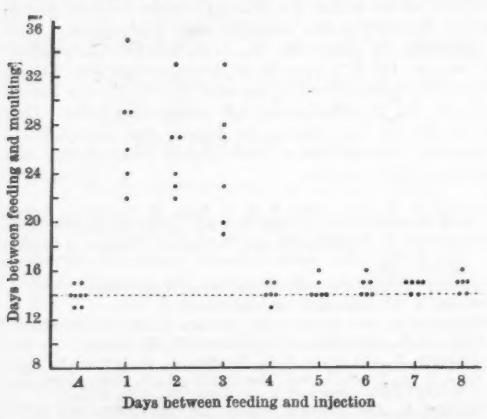

Fig. 1. Effect of blockage of the hæmocytes on the time between feeding and moulting in the 4th-stage larva of *Rhodnius*. 5 mm.³ of 2 per cent iron saccharate was injected into batches of six larvæ on the first to the eighth day after feeding. *A*, control batch of eight which received no injection

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Cambridge. Jan. 10.

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A Critical Response to Changing Length of Day in an Insect

In British populations of the emperor dragonfly, *Anax imperator* Leach, the final larval instar is usually entered in August. A diapause follows, and metamorphosis is postponed until the following spring. In this way, emergence of the adult is closely synchronized[1].

Close inspection of the time-frequency distribution of emergence has shown it to be bi-modal, and it has been established that the larvæ emerging in any one year are of two distinct types.

The first, major emergence group (Fig. 1, *A*) is composed of larvæ which have entered the final instar the previous year and have since completed diapause. The second emergence group (Fig. 1, *B*), which is developed to a variable extent from year to year, and which seldom comprises more than 10 per cent of the annual population, is made up of larvæ which have over-wintered in the penultimate larval instar, entered the final instar in spring, and emerged shortly afterwards.

That larvæ of the second group metamorphose without delay demonstrates that the diapause in the final instar must be facultative, being induced in summer and autumn, yet being averted in spring. In Nature, it was found that the latest date upon which the final instar was entered by a larva destined to forgo diapause was May 28. Since the duration of metamorphosis is known, a further check is provided by the latest dates of emergence, which are closely similar from year to year. From three years of observations there is strong evidence for concluding that diapause is averted in larvæ entering the final instar before June 1, but is induced after that date.

The seasonal incidence of diapause suggests that the environmental factor responsible for its determination is likely to be the sign of change in successive lengths of day. Preliminary experiments conducted in 1952 have lent support to this thesis. In these experiments, larvæ experiencing unchanging photoperiods of a length corresponding to July 31 responded in a fashion similar to those subjected to a regime of decreasing lengths of day, both groups entering diapause.

This observation suggests that, when daily increments fall below a certain threshold value, they are no longer appreciated as such, but are recorded by larvæ as being of constant length, until such time after the summer solstice as decrements begin to

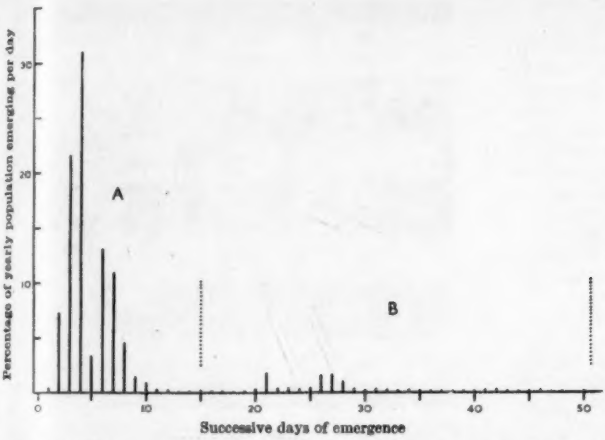

Fig. 1. Time-frequency distribution of adult emergences in a population of *Anax imperator* during 1952. *A*: Main emergence group provided by larvæ which had completed diapause. *B*: Subsidiary emergence group provided by larvæ in which diapause had been averted. Emergence began on May 17 and finished on July 5

exceed the threshold. If this is so, then the observation that diapause is induced after June 1 means that larvæ are unable to discern increments of less than about two minutes *per diem*.

Spring species have been defined as those possessing a diapause in the final larval instar[1]. For the diapause to be determined facultatively obviates the necessity for larvæ entering the final instar in spring to postpone emergence for one year; but, at the same time, it extends the emergence period. The extent to which the emergence period is lengthened will depend upon the value of the threshold increment of length of day that evokes a response. Members of a spring species in which diapause has been averted will possess the properties of summer species. Thus, in the first emergence group of *A. imperator*, emergence is closely synchronized whereas, in the second, it is temporally dispersed (see Fig. 1).

A. imperator is thought to be the first invertebrate in which a response to changing, rather than absolute, photoperiod has been discerned. It is noteworthy that previous studies on diapause have involved uni- or multi-voltine animals. For species having a larval duration of more than one year, it is probable that some factor more incisive than absolute photoperiod is required as a seasonal indicator. It is therefore likely that a similar response exists in other long-lived invertebrates of temperate regions.

This work was financed by the Department of Scientific and Industrial Research and is to be described more fully elsewhere.

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A Model of Cortical Activity

IN a study of the organization of the cerebral cortex, alternative experiments on the evoked potentials of the hippocampus and of the isocortex were performed in order to apply the findings in the more simply constructed layer of Ammons pyramids to resolution of the electrical fields of the cortex proper. The former consists essentially of one layer of similarly oriented cells[2], whereas the latter structure shows duplication in the form of stratified supragranular and infragranular layers. We have found that the electrical correlates of the layered isocortex are not in the direction that at first seemed obvious. For one thing, the d.c. standing potential across the unstimulated isocortex is less rather than greater than that across the pyramid cell-layer of the hippocampus, suggesting that the cell dipoles are not arranged in series. Furthermore, the overall potentials of activation of an area of the isocortex show an increase in magnitude during inactivation of the supragranular layer.

A consideration of some well-known facts will indicate the manner of derivation of the model. The supragranular layer is more variable than the infragranular, both between species[1] and between neighbouring cortical regions in the same species (unpublished work). The infragranular layers are everywhere more uniform, suggesting a protean function. The experiments of Murphy and Dusser de Barenne[2] show that motor function survives the destruction of the supragranular layers of the precentral cortex and demands only the integrity of the deep cells. This suggests that the topmost part of the cortex may be regulatory. Morphologically, the characteristic and unique type of cortical cell, the pyramids, has in its apical dendrite a feature which has not been accounted for in any previous model of cortical function.

In Fig. 1 is illustrated our finding that there is a release of the isocortex, in the reaction to an afferent

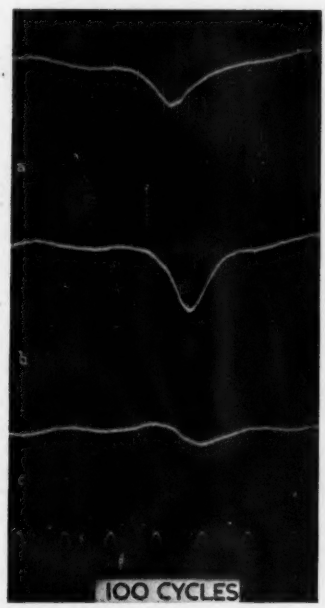

Fig. 1. Sequence of records from the sensory cortex of a rabbit evoked by stimulation of the sciatic nerve: (*a*) before, (*b*) during, and (*c*) after narcotization of the cortex with cyanide applied to the pial surface. Time in milliseconds

stimulus, following narcotization of the supragranular layers. This has been seen to occur with a variety of narcotic and poisonous agents, and in cortical activity evoked by stimulation of various afferent sources as well as via the corpus callosum. Rendering the surface layers of the isocortex subnormal by adequate stimulation has resulted in a similar release, or augmentation, of the activity.

To account for these experimental facts and to harmonize with the other relevant observations, we propose the following model of cortical activity. The potential differences maintained across the cell bodies of the cortical neurons are a measure of their polarization and regulate the firing pattern. Because the cortical cells have apical dendrites ramifying in the molecular layer, the successive tiers of cells are not in series, in so far as their electrical fields are concerned. Instead, the external current flow of the cells of one layer tend to reverse the polarization of members of the other and thus modulate their impulse discharge. In this way, the small and medium-sized pyramids of the supragranular layer act as a ballast to the efferent cells and inhibit their activation by the afferents. When the supragranular layer is thrown out of action, the cortical response is more vigorous.

The mechanism which we are postulating does not require the degree of discrete signal transference from cell to cell which is widely assumed. In this respect it fits in well with the results of our studies, for we have found, as Jasper (ref. 3, p. 146) has previously remarked, that cortical discharges evoked by stimulation of afferent pathways are surprisingly uncomplicated and uniform events. Such a fact is hard to reconcile with the idea that discrete bits of information trickle through the cortex. Thus both our findings and our interpretation lend support to those who feel that the relation of cortical activity to so complex a phenomenon as mentation must involve dynamic sequences such as the moving domains of Cragg and Temperley[4].

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Sialic Acids

In 1936[1] one of us (G. B.) isolated from bovine submaxillary mucin a crystalline reducing acid, later[2] named 'sialic acid'. Qualitative reactions indicate that sialic acid or substances closely related to it occur in most epithelial mucins, in ovomucin, in the glycoproteins of blood serum and in gangliosides[3]. Crystalline substances reacting like sialic acid have now also been isolated from porcine, ovine and equine submaxillary mucin. None of these products is, however, identical with any of the others—a fact already evident from the X-ray powder diagrams (Fig. 1).

The bovine sialic acid crystallizes in monoclinic rectangular plates, the others in needles or prisms. Although each substance appears microscopically

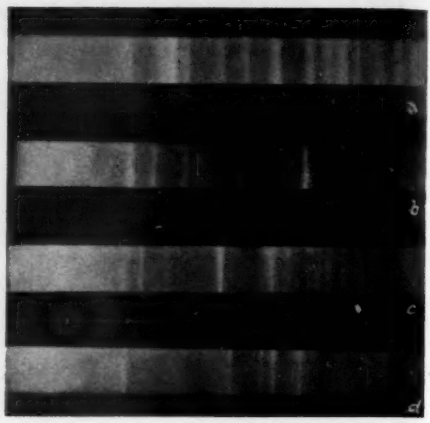

Fig. 1. X-ray powder diagrams of (*a*) bovine, (*b*) ovine, (*c*) porcine and (*d*) equine sialic acid

uniform and invariably gives in different preparations the same X-ray diagram, elementary analyses have not given values consistent enough to establish definitely the compositions. The most probable compositions are:

Bovine sialic acid, $C_{11}H_{21}NO_{11}$ (or $C_{11}H_{21}NO_{10}.H_2O$)
Porcine " " $C_{11}H_{19}NO_{10}$
Ovine " " $C_{11}H_{19}NO_9$

(The purified equine substance has not yet been obtained in quantities sufficient for elementary analysis.)

Bovine sialic acid contains an N-acetyl group, and an O-acetyl group which is very easily split off. The ovine substance has only an N-acetyl group, and the porcine acid no acetyl group but instead an N-glycolyl group. The glycolic acid was isolated and identified as the calcium salt.

Periodate splits off one primary alcohol group from sialic acids. On treatment with concentrated sulphuric acid, carbon monoxide is liberated—rather less than one mole per mole for bovine and ovine sialic acids and rather more than one mole per mole for the porcine substance. This probably indicates the presence of an α-hydroxy-group in each of them, and accounts for the glycolic acid in the porcine sialic acid.

Titration with hypoiodite, as described by Willstaetter-Schudel, indicates the presence of an aldehyde group. This conforms with the finding that on treatment with sodium borohydride approximately one molecule of hydrogen is taken up per molecule of sialic acid. The Schiff reaction with fuchsin-sulphurous acid (as modified by Tobie[4]), however, is only very faintly positive for bovine sialic acid, and is negative for the other two.

After reduction of sialic acid with sodium borohydride, subsequent treatment with dilute hydrochloric acid at 100° produces no reducing substance. This almost excludes the presence of a glycosidic linkage in the molecule. The presence of three end-groups and the almost certain absence of a glucosidic linkage suggest a branched carbon chain in the molecule. The infra-red spectra have given no additional clue to the structure. Only end-absorption starting at about 2500 A. is seen in the ultra-violet.

The optical rotations of the ovine and porcine sialic acids remain constant at room temperature, whereas that of the bovine acid changes very slowly,

probably owing to decomposition or ring-formation. The substances melt with simultaneous decomposition, already showing some browning below the decomposition point.

	$[\alpha]_D^{20}$	Decomp. point
Bovine sialic acid	+ 8° ± 2°	152–153° (uncorr.)
Porcine „ „	− 31° ± 2°	185–187° „
Ovine „ „	− 32° ± 2°	185–187° „

The 2-carboxy-pyrrole found by Gottschalk[5] as a product of splitting on alkaline hydrolysis of submaxillary mucin is no doubt formed by a cyclization process during the alkaline decomposition of sialic acid. The neuraminic acid of Klenk[6], the hæmataminic acid of Yamakawa and Suzuki[7], and the lactaminic acid of Kuhn[8] obviously all bear a very close relation to sialic acid. The first two probably simply represent de-acetylated sialic acids.

A detailed report of this work will appear elsewhere.

Note added in proof. The assumption of the presence of a branched carbon chain in the sialic acid molecule has received additional support by recent micro hydroxyl-group determinations. These revealed six hydroxyl groups per molecule in the porcine sialic acid and five in that of the bovine substance.

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Biological Decomposition of Aromatic Nitro-compounds

Certain organic nitro-compounds, for example, chloramphenicol, are known to arise biologically; but very little is known about the transformation of this class of compounds by micro-organisms. Erikson[1] and Moore[2] found that certain Actinomycetes could utilize picric acid, trinitroresorcinol, and nitrobenzene, and Simpson and Evans[3] have reported briefly on species of *Pseudomonas* that decompose *o*- and *p*-nitrophenol with the formation of nitrite; the last workers also mention nitrite production from 2,4-dinitrophenol and chloramphenicol.

According to a personal communication from Mr. H. Ingvard Petersen (Government Weed Research Department, Lyngby, Denmark), the herbicide dinitro-*ortho*-cresol is rapidly inactivated in soil, apparently by biological agencies, whereas the chemically related herbicide dinitrobutylphenol appears more persistent. From the soil used in these detoxication experiments, we have isolated an organism that decomposes 4,6-dinitro-*ortho*-cresol and several related compounds with release of nitrite.

The organism appears in young cultures as a non-spore-forming, Gram-positive, irregular rod, approximately 1·4–4·0 μ × 0·6–0·8 μ, in characteristic angular or parallel arrangements; the cells in older cultures become shorter or almost coccoid, 0·7–1·3 μ in diameter. Taxonomically, it seems to be an atypical form of *Corynebacterium simplex*[4]. Decomposition of dinitro-*ortho*-cresol in solution as well as in agar medium is evidenced by the bleaching of the yellow colour and the appearance of nitrite. Growth is possible in a synthetic medium with no other organic constituents than 0·01–0·05 per cent dinitro-*ortho*-cresol (as sodium salt), but is slow and unreliable under these conditions; addition of 0·01–0·1 per cent yeast extract greatly accelerates growth and nitrite formation. The results of an experiment in liquid medium with 0·02 per cent dinitro-*ortho*-cresol and 0·01 per cent yeast extract are shown in Fig. 1. (Nitrite and residual dinitro-*ortho*-cresol were both determined colorimetrically on a Coleman spectrophotometer, the former by means of the Gries reagent, the latter directly by the intensity of the yellow colour.)

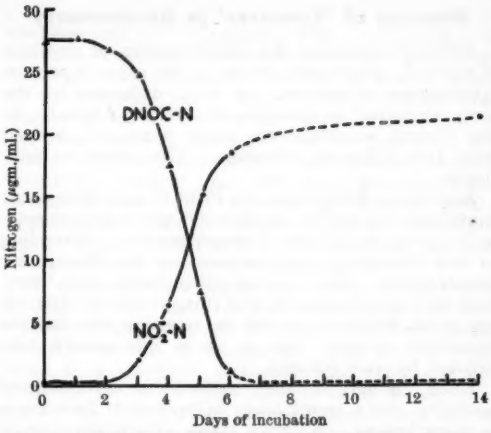

Fig. 1. Production of nitrite from dinitro-*ortho*-cresol (approx. 10^{-3} *M*) by *Corynebacterium* sp. (*simplex* ?) in liquid medium incubated at 25° C.

Besides 4,6-dinitro-*ortho*-cresol, the organism decomposes *p*-nitrophenol, 2,4-dinitrophenol, and 2,4,6-trinitrophenol (picric acid), but not *o*- and *m*-nitrophenol, 2,5- and 2,6-dinitrophenol or 3,5-dinitrobenzoic acid. Thus only compounds with a nitro-group in the *para*-position appear liable to attack; we have not, however, been able to detect nitrite formation from 4,6-dinitrobutylphenol, which also seems to be less readily inactivated in soil, as mentioned above. The results in Fig. 1, as well as similar experiments with dinitrophenol, show that more than half the nitrogen in dinitro-compounds is converted into nitrite, that is, both nitro-groups are metabolized. Possibly the *p*-group represents the point where the enzymatic attack begins and the ring-structure is broken, with subsequent release of the second nitro-group.

The results of these experiments will be published in detail elsewhere.

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Meaning of 'Turnover' in Biochemistry

Hevesy[1] considers the determination of the rate of renewal, or turnover, as one of the most important applications of tracers. A clear definition of the term 'turnover' is therefore of obvious interest. In the present literature the term 'turnover' is used with two different meanings. This leads to confusion.

Zilversmit, Entenman and Fishler[2], and later other workers in Chaikoff's laboratory[3,4], use 'turnover-rate' as a synonym of rate of disappearance. According to this definition, turnover-rate has the dimension: amount/time. Siri[5], on the other hand, uses 'turnover-rate' as the reciprocal of turnover-time. According to his definition, therefore, turnover-rate has the dimension 1/time, that is, it is Zilversmit's rate divided by pool content.

Even though it may not have chronological seniority, Siri's terminology is preferable because it is more logical. We may speak of transfer-rate or exchange-rate from one pool to another, or rate of disappearance from one pool, and can say, for example, how many atoms (or grams) of phosphorus are exchanged per unit of time or disappear from a pool per unit of time; and the rate of turnover is the number of times a given pool of, say, phosphorus atoms is turned over, or is renewed, per unit of time. As the rate of turnover of a wheel (presumably the original for the analogy) is the linear velocity of the car divided by the circumference of the wheel, so the rate of turnover of a metabolic pool is the transfer-rate divided by the pool content.

If the concentration of tracer changes as a first-order process:

$$\frac{d\alpha}{dt} = k\alpha,$$

where α is concentration of tracer (that is, specific activity) and t is time, then k stands for the 'rate constant' in the terminology of chemical kinetics.

If the change in tracer concentration is the result of a transfer process with a constant rate of transfer, a (amount per unit time), from a constant pool content, A, then:

$$k = \frac{a}{A},$$

where a/A is the relative rate of transfer. Then,

$$\frac{\text{amount/time}}{\text{amount}} = \frac{1}{\text{time}}.$$

This relative rate of transfer tells what fraction of the pool content, A, is transferred per unit of time or, if a is larger than A, how often the pool content A is turned over per unit of time. This relative rate of transfer is therefore properly called 'turnover-rate'. Its reciprocal A/a shows how much time is required for one turnover of a pool of content A. This is the 'turnover-time'.

'Renewal-rate' is a synonym of 'turnover-rate', and a similar argument applies for its definition. In tracer work we do not study renewal of atoms but of pools, and the renewal-rate should show how many times a pool is renewed per unit of time.

It is suggested that for the sake of clarity in terminology, the term 'turnover-rate', or its synonym 'renewal-rate', be used exclusively as an index for the number of times the content of a pool turns over or is renewed, which is the reciprocal of time of turnover.

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Feulgen-negative Nuclear Division in *Habrobracon* Eggs after Lethal Exposure to X-Rays or Nitrogen Mustard

The females of the parasitic wasp *Habrobracon juglandis* (Ashmead) when well fed will store eggs in the first meiotic metaphase (metaphase-1) and retain them until the female is placed with the host[1]. The unfertilized eggs develop into viable haploid males. When the untreated egg is oviposited, meiosis proceeds and the pronucleus is formed 30 min. after oviposition at 30° C. The nuclei divide synchronously at the rate of approximately one division every 15 min. At the ninth or tenth cleavage stage (2½–3 hr. after oviposition) most of the nuclei migrate to the egg periphery. After two or three more divisions, cell membranes slowly form between the nuclei, and tissue differentiation begins. The embryo hatches about thirty hours after oviposition and feeds on the paralysed host.

In the present experiments, well-fed females were treated with X-ray exposures of 10 kr. (1·5 kr./min.) or an equivalent dose of nitrogen mustard (prophase-1 hatchability was criterion[2]). This exposure is approximately five times the lethal dose for metaphase-1 oocytes. The X-rays were delivered by a G. E. Maxitron-250 unit operating at 250 kVp., with a tungsten target and 1 mm. aluminium inherent and 3 mm. of aluminium added filtration (half-value layer, 0·55 mm. copper); the nitrogen mustard (kindly supplied by Merck and Co.) was delivered in the form of an aerosol. The subsequent development of eggs which were in metaphase-1 during the time of treatment was studied; the eggs were fixed in Kahle's fluid at various times after oviposition and were stained according to the Feulgen procedure after optimum hydrolysis in 1 *N* hydrochloric acid.

More than 95 per cent of the eggs treated with X-rays and all eggs treated with nitrogen mustard were identical in their developmental pattern. Meiosis proceeds at a normal rate, even when chromosome bridges are present. The first cleavage is partially inhibited, particularly but not specifically at metaphase, for one to two hours after oviposition—nuclear division then slowly proceeds until two to eight Feulgen-positive interphase or prophase nuclei are present, usually near the anterior end of the egg. At approximately the eighth hour after oviposition, ooplasmic areas can be seen within the yolky egg interior. These areas are ordinarily diagnostic for cleavage nuclei; but nothing definite can be recognized within them except for occasional spindle-like structures. By the ninth or tenth hour, Feulgen-

negative bodies which are otherwise identical with interphase nuclei begin to appear in the ooplasmic areas. These become distributed throughout the yolky interior. By the tenth or twelfth hour, 50–150 of the Feulgen-negative nuclei have appeared, and they begin to enlarge gradually. The two to eight Feulgen-positive nuclei can occasionally be detected at this stage, and they also usually enlarge. When nuclear enlargement begins, apparently no more Feulgen-negative nuclei are formed. At twenty hours after oviposition, enlargement of the Feulgen-negative nuclei is nearly maximal (up to 200 times the normal volume) and the Feulgen-positive nuclei are usually not easily detectable.

It has been known for several years that, at lethal exposures, both X-rays and nitrogen mustard more or less immediately and specifically interfere with deoxyribonucleic acid synthesis, whereas other intracellular syntheses are not directly disrupted[2]. It is probable, therefore, that the strange lethal action of these mutagens on the *Habrobracon* egg is intimately associated with a failure in synthesis of deoxyribonucleic acid. The presence of a few Feulgen-positive nuclei militates against the possibilities that deoxyribonucleic acid is too diffuse to be detected, or that the original pronuclear chromosomes undergo segregation and nuclear division ends with equal and complete distribution of the deoxyribonucleoprotein strands. It may be that the characteristics of deoxyribonucleic acid are changed by mutagens so that hydrochloric acid hydrolysis, necessary for removal of purine prior to aldehyde–fuchsin coupling, removes most of, or all, the deoxyribonucleic acid; this hypothesis appears to be contrary to available information[4]. Perhaps synthesis of deoxyribonucleic acid has been blocked by nitrogen mustard or X-rays, and the new nuclei are products of other reduplicating systems which are synthesized and replicated until deoxyribonucleic acid is required for further development. This proposal must be regarded with considerable caution, since the participation of deoxyribonucleic acid in genetic continuity is a well-established phenomenon[5].

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Chromosomes and Nucleoli in *Pisum sativum*

Since the beginning of the century, reports have been published in which an ideogram has been given, or at least the morphology of the chromosomes has been described, of *Pisum sativum*. With improved techniques and with a better understanding of chromosome structure, it is reasonable to suppose that recent workers would be in agreement. In the latest observations[1], all authors agree that there are fourteen chromosomes in a normal diploid cell; but here agreement ends. There is disagreement over the positions of the centromeres, the number of chromosomes with satellites, and the position of these satellites and their connexion with the nucleoli. In addition, a number of secondary constrictions (non-nucleolar) have appeared from time to time in nearly all the chromosomes. The majority of these constrictions can, we believe, be traced to the action of the drugs used on the cells prior to fixation. The doubts over the relationship of satellites and nucleoli have been prevalent since 1942, when Häkansson and Levan[2] reported that nucleoli are formed at the centromeres of all the chromosomes and that the visible constrictions in the chromosomes are not associated with nucleolus formation.

To facilitate the examination of the chromosomes at mitosis, we used monobromonaphthalene and 0·05 per cent colchicine to disorganize the spindle and shorten the chromosomes. The use of these drugs is a standard technique and they are not known to produce extra constrictions in the chromosomes. La Cour's 2 *BE* proved superior to 2 *BD* or acetic alcohol as a fixative. Staining with Feulgen was also superior to either aceto-carmine or aceto-orcein for mitosis. Fast green was used as a counter stain to show nucleoli.

In the diploid somatic cells, there are usually one or two nucleoli, and occasionally three or four, but never more. As corroborative evidence, no more than two nucleoli per nucleus have been observed in the haploid pollen grains. Contrary to a previous report[3], we did not find extra nucleolar bodies in the cells at root-tip mitosis, nor did we observe persisting nucleoli at metaphase or anaphase stages of division. Two pairs of the chromosomes have nucleolar constrictions and thus have satellites, one pair of satellites being smaller than the other. Both pairs are on the long arms of the chromosomes. At prophase the attachment of the four chromosomes to the nucleolus, or nucleoli, leaves no doubt that they are definitely associated with nucleolus formation. Other secondary constrictions were not observed in any chromosomes. In the longest pair of chromosomes the centromere is submedian. There are two short pairs with median or near median centromeres, and one longer pair with a definite subterminal centromere. In the remaining pair the centromere is subterminal, but not as markedly as in the nucleolar chromosomes. After contraction with drugs, the longest chromosome is only about 4 μ long, and it is therefore difficult and sometimes impossible to pick out all the individual chromosome pairs in a cell. Our ideogram (Fig. 1) is therefore presented with a certain amount of reservation. In other words, we are unprepared to say that we can distinguish between several chromosomes that are within 0·5 μ of each other in length. Our ideogram is substantiated by the sizes and shapes of the chromosomes at second anaphase of meiosis and at mitotic anaphase in pollen grains.

Our squashes of meiotic stages were stained with aceto-carmine and sometimes also with fast green. At prophase only one or rarely two nucleoli are formed. Frequently they are cap-shaped. The prophase division stages are abnormal in that the chromosomes are indistinct and diffuse from after

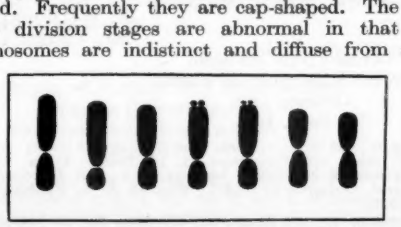

Fig. 1. An ideogram of the chromosomes of *Pisum*

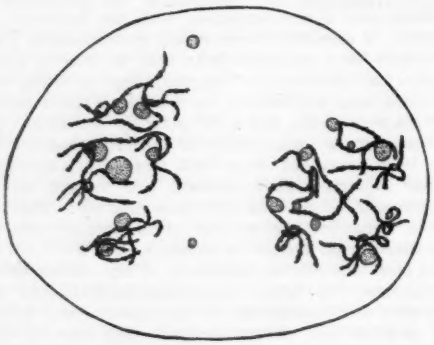

Fig. 2. Late prophase of second division of meiosis. Note the number and the positions of the nucleolar bodies on the chromosomes. × 1,000

pachytene until just prior to first metaphase. Along with this condition there is an obvious granular appearance of the nuclear contents. At first telophase a nucleolar-like substance appears interspersed with the chromosomes. During the short resting-stage and the prophase of second division, this substance forms into distinct globules which are associated with the chromosomes (Fig. 2). At the same time there are several smaller bodies lying free in the cytoplasm. In the nucleus they vary in number from one to twelve. There may be one formed on each chromosome; there may be two or three or none. What we wish to emphasize is that the bodies arise from the substance that first appears at telophase. They are not formed at specific loci of the chromosomes. We therefore disagree with Häkansson and Levan, and with Marshak, who reported that the nucleoli were formed at the centromeres of each chromosome. These nucleolar-like bodies disappear at second metaphase and reappear at the following telophase. They are present again both inside and outside the nucleus at the tetrad stage. They are, however, reduced in number in the nucleus. The most we have seen is five.

The existence of nucleolar-like bodies or 'telophase globules' is not confined to *Pisum*. We have also seen them in *Zea mays* and in *Phaseolus*, and they have been reported in several species of *Fritillaria*[3].

The nucleolar substance stains like normal nucleoli; the globules appear and disappear at the same stages of division as the nucleoli. They are, in fact, indistinguishable with nucleoli but are not confined to specific loci. However, in the root meristems, at prophase of mitosis in pollen grains and probably at prophase of meiosis, the formation of nucleoli is directly associated with specific loci, that is, the nucleolar constrictions. A special system of nucleolus formation may be operative in some species of plants, or may be operative in all species but more obvious cytologically in some.

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Use of the Mouse for Detection of Small Numbers of Tubercle Bacilli

Following early experiments[1], it was considered that the mouse was one of the animals most resistant to tuberculosis. More recently, it has been found that the mouse could be readily infected by the intravenous route[2], or by inhalation[3], but it was still considered to be highly resistant to subcutaneous infection. It was found[4] that *C57* black mice, maintained on a deficient diet and infected intranasally, were as sensitive as the guinea pig for the detection of small numbers of tubercle bacilli. The small lesions produced in the lungs had to be examined microscopically, as non-specific lesions sometimes occurred; in tuberculous lesions there were, of course, numerous bacilli.

The mouse is obviously more economical to use than the guinea pig, but the breeding and maintenance of *C57* mice on a deficient diet and their intranasal inoculation have certain disadvantages for routine work; an attempt was therefore made to develop simpler methods. It is well known that tubercle bacilli multiply freely in the mouse, but sometimes produce very slight lesions. Carbon was therefore added to the suspensions of tubercle bacilli so that the position of the inoculum could be seen. In preliminary experiments mice were infected by the intravenous, intraperitoneal, intrapulmonary and subcutaneous routes.

Carbon was found to be of no special value following intravenous infection, and direct intrapulmonary injection was not regularly successful. Aggregates of carbon were readily found in the omentum following intraperitoneal infection, and sometimes the bronchial lymph nodes contained much carbon, but multiplication of bacilli was not great in these sites. The site of inoculation was readily found following subcutaneous (or often intramuscular) infection and, rather surprisingly, it appeared that multiplication of bacilli was abundant and regular, so a more extended series of experiments was performed.

Cultures were grown on Loewenstein's medium, weighed when moist, and emulsified in distilled water containing 1 per cent serum. Dilutions were made in this fluid, to which carbon had been added. Each mouse, guinea pig or culture tube was inoculated with 0·1 c.c. of dilution. Mice and guinea pigs were killed at intervals and smears made from the small black foci in the subcutaneous or intramuscular tissues and from the regional lymph nodes. Cultures were examined at the same time.

Doses of 10^{-4} to 10^{-6} mgm. of human tubercle bacilli were used, and the smallest dose gave negative results in mice, guinea pigs, and on culture tubes. Doses of 10^{-7} mgm. produced growth on only two or three of four tubes of Loewenstein's medium and produced no lesions in one of four guinea pigs. Bacilli were, however, found in all eight mice killed three to six weeks after infection, and in the last mouse small clumps of bacilli were found easily, and there were numerous isolated bacilli. Doses of 10^{-8} mgm. produced growth on only two or three of four tubes of Loewenstein's medium, but all guinea pigs became infected. Bacilli were readily detected in mice two weeks after infection and were numerous after four weeks. Doses of 10^{-4} and 10^{-5} mgm. produced growth on all culture tubes, and bacilli were numerous in mice two weeks after infection. Bovine tubercle bacilli multiplied rather more rapidly than human tubercle bacilli in mice.

Myco. phlei and four other strains of saprophytic acid-fast bacilli were injected in doses of 10^{-2} to 10^{-4} mgm. With the larger doses, smears from the inoculum revealed many acid-fast bacilli and these were, of course, detected in mice two weeks later. After four weeks there were, however, slightly fewer bacilli. With doses of 10^{-4} mgm. very few bacilli were seen at all; the results were therefore very different from those obtained with virulent tubercle bacilli.

In this work three separate laboratory strains of white mice, maintained on stock diets, have all been equally susceptible. Mice varying in age from three weeks to 'adult' were used, and although the young mice appeared to be slightly more susceptible, the difference was considered to be unimportant.

No evidence has been obtained to conflict with the view that it is difficult to produce generalized tuberculosis in mice following subcutaneous infection; but the foregoing results indicate that, if smears are made from the site of inoculation, it may be possible to use mice for the routine detection of small numbers of virulent tubercle bacilli. The method is now being tried on clinical material.

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Larvæ of *Sphaerophoria* as Predators on Thrips in South Africa

IN an earlier paper[1] attention was directed to the fact that thrips have remarkably few effective natural enemies. Syrphidae were mentioned as predators; but the thrips-feeding habit seems to be very rare in these insects, the larvæ of most of the entomophagous forms feeding on aphids and other Homoptera. Some Syrphid larvæ, however, are known to prey on other insects, such as caterpillars; but there seem to be scarcely any records of species feeding on thrips. Where thrips are rather inactive and congregated in numbers on leaves or in galls, they would seem to be more liable to attack by predators such as Syrphid larvæ.

At Grahamstown, Cape Province, South Africa, larvæ of the Syrphid fly, *Sphaerophoria quadrituberculata* Bezzi (Diptera, Syrphidae), were observed feeding on the immature stages of the thrips, *Cercothrips afer* Priesner, in curled leaves of a plant originally thought to be *Ficus burtt-davyi* Hutch., but now identified as *Ficus craterostoma* Warburg. All the Syrphid larvæ found were in the third or final instar, and were nearly fully grown. They were kept in glass dishes in the laboratory and supplied with thrips several times a day. The thrips larvæ, prepupæ and pupæ were eaten voraciously, the Syrphid larvæ striking out vigorously in all directions until contact was established with the prey; but the adult thrips were not attacked. This appears to be the first record in Africa of the thrips-feeding habit in Syrphidae. Prof. J. C. Faure, Dr. E. K. Hartwig and Mr. J. C. Jacot-Guillarmod kindly inform me (*in litt.*, 1954) that they have never observed or know of any records of Syrphid larvæ feeding on thrips in South Africa.

Cercothrips afer is large for a thrips and is a most conspicuous species. The immature stages are bright red, whereas the adults are black and attain a length of 7 mm. Although this thrips may occur in considerable numbers in the curled leaves of *F. craterostoma*, it lives there as an inquiline, and is not in any way responsible for the curling. Actually the curling of the leaves results from the feeding activities of another and smaller thrips, *Gynaikothrips hirsutus* (Karny). This thrips, too, is often very numerous in such curled leaves, which can really be termed open galls, for the inward rolling of the edges of the leaves is accompanied by marked hypertrophy of the plant tissue. Both thrips have been recorded previously from South Africa. Jacot-Guillarmod[2] found *Cercothrips* associated with *Gynaikothrips* on *Ficus petersii* Warburg in Natal; but, although he suggested the curling of the leaves was probably due to the latter species, he did not state definitely that *Cercothrips* lives as an inquiline in the curled leaves. My observations leave no doubt as to the respective parts played by the two species of thrips.

Although the Syrphidae include some of the most important of beneficial insects, they have as yet been little studied in Africa. As in other parts of the world, however, the larvæ of the entomophagous species will probably be found to be mainly aphidophagous. The genus *Sphaerophoria* is world-wide in distribution, and its larvæ are known to be predators on aphids and other homopterous insects. Only two species of *Sphaerophoria* appear to have been recorded so far from the Ethiopian region. *Sphaerophoria quadrituberculata* is a remarkable species. It was described by Bezzi[3] in 1915 from Durban, Natal, but does not seem to have been found since. The males are unusual in having a pair of large, conspicuous, raised tubercles on both the third and fourth tergites of the abdomen, to which the specific name directs attention. The structure of the immature stages, described recently by Stuckenberg[4], is equally remarkable, and the thrips-feeding habit of the larvæ is exceptional. The feeding habits of this species were hitherto unknown. Curled leaves present a highly specialized environment, and it would be interesting to know if the larvæ of this Syrphid occur in habitats other than galls and prey on insects other than thrips. It seems not unlikely, however, that the larvæ of this species are restricted to this ecological niche in curled leaves and feed exclusively on thrips.

I am grateful to Mr. C. F. Jacot-Guillarmod for naming the two species of thrips, and to Dr. L. E. W. Codd for the identification of *Ficus craterostoma*. Mr. B. R. Stuckenberg kindly identified the Syrphid and described its immature stages, which were previously unknown.

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Alkaline-Earth Borohydrides and their Applications in Organic Syntheses

We have pointed out that the alkaline-earth metal borohydrides discovered by us are very suitable for the reduction of ketones and aldehydes to the corresponding alcohols[1]. The present communication deals with the application of these borohydrides—particularly of $Ca(BH_4)_2$—for reduction of other functional groups.

The most important of these applications is the reduction of carboxylic acid esters to primary alcohols. We have been able to reduce a great number of aliphatic and aromatic carboxylic esters, generally in excellent yields, by means of calcium borohydride. For example, we have reduced the following esters to the corresponding carbinols (yields in parentheses): ethyl *p*-nitrobenzoate (96 per cent), ethyl phenylacetate (90 per cent), ethyl glycinate (70 per cent), ethyl alaninate (73 per cent), threo ethyl *p*-nitrophenylserinate (88 per cent); for this last reduction, lithium–aluminium hydride is quite unsuitable[2].

The azlactones, too, proved to be well suited for reduction by the aid of calcium borohydride[3]; 2-phenyl-4-benzyliden-oxazol-5-one gave α-benzoyl-aminocinnamyl alcohol.

The above-mentioned reductions can be carried out with solutions of calcium borohydride in hydroxyl-free solvents (tetrahydrofurane); but the alcoholic solutions prepared by the metathesis of sodium borohydride and calcium chloride are equally suitable. In alcoholic medium, of course, to avoid the alcoholytic decomposition of the calcium borohydride, the temperature must be kept between about −20° and −10° C. (Esters with smaller reactivity are not reducible in alcoholic solution.)

It is very interesting that the reductions can also be successfully carried out in solvents of high water content (for example, in 50 per cent alcohol) provided that the temperatures employed are sufficiently low; thus threo ethyl-β-phenylserinate and ethyl *p*-nitrobenzoate are reducible in 50 per cent ethanol with good yields. The reductions are generally completed in 4–10 hr.

If required, it is possible to work in a hydroxyl-free solvent by the following technique: the solution of the ester in tetrahydrofurane is stirred for some hours with a mixture of calcium iodide and sodium borohydride at a temperature between 0° and 25° C., or, if necessary, at higher temperature. Obviously the reducing agent is 'nascent' calcium borohydride.

We have developed further methods for preparing the alkaline-earth metal borohydrides in solid form. For example, calcium borohydride can be obtained from the reaction of anhydrous calcium chloride and sodium borohydride in tetrahydrofurane. The reaction requires 4–8 hr. and thorough stirring (with a magnetic stirrer or a ball mill). The solution contains, after the sodium chloride has been centrifuged off, calcium borohydride of fairly good purity. (With such solutions esters with smaller reactivity, such as ethyl benzoate, are also reducible). The solution gives on evaporation *in vacuo* a crystalline tetrahydrofurane addition compound of calcium borohydride.

The reducing properties of strontium or barium borohydrides are very similar to those of calcium borohydride.

Our experimental results indicate that the calcium borohydride and other alkaline-earth metal borohydrides are reducing agents of higher reducing activity than the other borohydrides hitherto used for reduction purposes, namely, the borohydrides of sodium, potassium and lithium. This may be ascribed perhaps to the more covalent character of these compounds.

The general opinion, that esters are not reducible with sodium or potassium borohydride[4], must be corrected. In our experiments, we succeeded in reducing some esters with sodium and lithium borohydrides in alcoholic solution to primary alcohols in excellent yields. Nevertheless, some esters, which are readily reduced by alkaline-earth borohydrides, are not reducible by means of lithium or sodium borohydrides under similar conditions.

The alkaline-earth metal borohydrides are, in our opinion, among the most important reducing agents. They are suitable for the reduction of esters to primary carbinols, a reaction which is regarded as the most important function of lithium–aluminium hydride. In addition, the alkaline-earth borohydrides have a combination of features which is unique: solvents with hydroxyl groups (for example, ethanol, water) may be used; the selectivity of the reductions is greater than in the case of lithium–aluminium hydride; there is no danger of explosion and ignition, as contrasted with the latter; compounds sensitive to alkalis can also be reduced, as the solutions of alkaline-earth borohydrides are nearly neutral.

We believe that these compounds have good promise, *inter alia*, in the study of several groups of natural products, such as the proteins, polypeptides (determination of C-terminal residues[5]), sugar derivatives and polysaccharides.

A detailed account of this work will be published elsewhere.

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Inhibition of the First Limit of the Hydrogen – Oxygen Reaction by Ethane

A study of the inhibiting action of ethane on the second limit of the hydrogen–oxygen reaction in vessels coated with potassium chloride[1] shows that the main features of the inhibition are essentially similar to those reported for propane[2]. The reduction in explosion pressure with increasing mole fraction of ethane is almost exactly linear, and the quantity of inhibitor ($i_{1/2}$) required to halve the explosion pressure is approximately proportional to the mole fraction of oxygen, and approximately independent of the mole fraction of hydrogen, vessel diameter, and vessel surface. As in the case of propane, these main facts can be explained by introducing a termination reaction between hydrogen atoms and the hydrocarbon

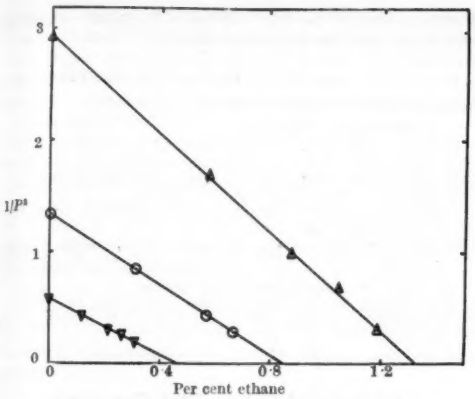

Fig. 1. 36 mm. diameter potassium chloride-coated vessel. Temperature 540° C. Mole fraction hydrogen, 0·28. Mole fraction oxygen (y) = 0·56 △ ; y = 0·28 ○ ; y = 0·14 ▽

into the accepted mechanism for the uninhibited second limit[3], when the relation obtained is :

$$i_{1/2} = k_1 y/k_2, \qquad (i)$$

where y is the mole fraction of oxygen, and k_1, k_2 are the velocity constants of reactions (1) and (2) :

$$H + O_2 = OH + O \qquad (1)$$

$$H + C_2H_6 = C_2H_5 + H_2. \qquad (2)$$

This treatment assumes that every radical produced in reaction (2) is destroyed without chain propagation ; allowance for this assumption can be made by introducing a term Q, the fraction of ethyl radicals destroyed without chain propagation, into the denominator of equation (*i*). As with propane, second-limit results give no indication of any significant variation of Q with mixture composition, vessel diameter or vessel surface, and the fate of the ethyl radicals thus remains uncertain.

In an attempt to examine the fate of the ethyl radicals at low pressures, the inhibition of the first limit by ethane was investigated. A simple expression can be obtained if the following assumptions are made : (*a*) only hydrogen atoms are destroyed at the vessel surface ; (*b*) this surface destruction is efficient, and is thus inversely dependent on the pressure ($k_H = A/P$) ; (*c*) gas phase termination through the termolecular formation of HO_2 is negligible ; (*d*) reaction of oxygen atoms and hydroxyl radicals with ethane can be neglected. The expression then obtained is :

$$2k_1 y = k_2 i Q' + A/P^2, \qquad (ii)$$

where Q' is the fraction of ethyl radicals destroyed without chain propagation at first-limit pressures.

Table 1

Hydrogen	Mole fraction Oxygen	Nitrogen	Ratio $I/2i_{1/2} = Q/Q'$
0·28	0·14	0·58	0·87
0·28	0·28	0·44	0·98
0·28	0·56	0·16	0·99
0·44	0·56	—	0·93
0·14	0·56	0·30	0·97
0·10	0·56	0·34	0·98
0·07	0·56	0·37	1·04
0·56	0·14	0·30	0·80
0·14	0·14	0·72	0·87
0·07	0·14	0·79	0·84

Fig. 1 shows the linear relation obtained when $1/P^2$ is plotted against i. The intercept when $1/P^2 = 0$ is given by $I = 2k_1 y/k_2 Q'$, and the ratio $I/2i_{1/2}$ thus gives Q/Q'. Table 1 gives this ratio for a wide variety of mixtures, and shows that Q/Q' is effectively constant, and equal to unity. Since the first-limit measurements cover the pressure range 5–20 mm. mercury, while the second-limit measurements cover the range 50–100 mm. mercury, it may be concluded that over the whole of this pressure-range the fraction of ethyl radicals destroyed is effectively constant.

The combination of first- and second-limit results thus suggests that Q is independent of pressure, mixture composition, vessel diameter and vessel surface. It is concluded that the ultimate termination reaction is :

$$C_2H_5 + O_2 = C_2H_4 + HO_2, \qquad (3)$$

and in consequence, the only possible competing chain propagation reaction can be a reaction with oxygen such as :

$$C_2H_5 + O_2 = CH_3CHO + OH, \qquad (4)$$

the fraction Q then being given by :

$$Q = k_3/(k_3 + k_4).$$

The high yields (up to 80 per cent) of ethylene obtained in the oxidation of ethane at these temperatures[4], as well as the kinetic facts (Baldwin, R. R., and Simmons, R. F., unpublished work), require reaction (3) to be at least as fast as reaction (4).

A detailed treatment, in which allowance is made for the assumptions (*a*)–(*d*) above, confirms these conclusions, and will be published shortly.

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Photosensitivity of Iron Chelates

During work with iron chelates, it was noted that many chemical analyses for total iron were inconsistent when repeated at intervals on solutions left standing on the laboratory bench in the light. A sensitive method was then devised for the estimation of the chelated iron molecule as a whole, based on the light-absorption of solutions in the ultra-violet region. Dilute solutions (approximately 0·0001 *M*) of the di-sodium iron ethylenediaminetetracetate have an absorption curve with a maximum at about 260 mμ. This peak is well separated from, and is much more pronounced than, that of the di-sodium ethylenediaminetetracetate itself at about 210 mμ. Therefore, the optical density at 260 mμ, as determined by a spectrophotometer, was used as a measure of the chelated iron present in solutions of the di-sodium iron compound.

Solutions of two other iron chelates, namely, those with diethylenetriaminepentacetic acid and with N-hydroxyethylethylenediaminetriacetic acid, can be analysed similarly by determining optical densities at their ultra-violet maxima of about 260 mμ and 245 mμ respectively. It has been noted by using the above method that solutions of these three iron chelates, although they are completely stable in the dark, are decomposed on exposure to daylight, thereby accounting for the inconsistent chemical analyses mentioned above.

Other metal chelate solutions tested so far, namely, those of copper and nickel with ethylenediaminetetracetate, are stable in light.

The photosensitivity of di-sodium iron ethylenediaminetetracetate has been noted previously by Jones and Long[1]; but this important point seems to have been overlooked by biologists. The proposed scheme for this decomposition, as published[1], is:

(i) Ferric-EDTA + light ⟶ Ferrous-EDTA + decomposition products of EDTA.
(ii) Ferrous-EDTA + ½ H_2O + ¼ O_2 ⟶ Ferric-EDTA + OH'
(iii) By repeated photoreduction and subsequent re-oxidation, sufficient hydroxyl ions are released to form the hydroxy-compound, Fe(OH)EDTA, and finally to precipitate ferric hydroxide.

Results I have obtained with the ultra-violet absorption method on solutions of di-sodium iron ethylenediaminetetracetate exposed to light are in accord with the above scheme, except that no decomposition of the ethylenediaminetetracetate molecule has been recorded. It is therefore of prime importance in quantitative laboratory experiments that solutions of these iron chelates should be protected from the action of light.

Another practical point is that vessels in which solutions of iron chelates have been decomposed by light acquire a tenacious deposit of iron hydroxide. This deposit is best removed by an acid rinse, being little affected by the normal wash with water and detergent.

The three iron chelates mentioned above have been used as a source of iron for plants[2,3]. Their mode of action is not understood; but it is thought that plants absorb through their roots the whole chelate molecule and translocate it intact[4]. There is, however, no evidence to show how plants obtain the iron from this very stable complex (log K of the ferric compound = 25·1 [5]). It has been postulated that the iron is only released after the ethylenediaminetetracetate has been partially metabolized[6]; alternatively, a more stable complex would have to be formed.

In view of the photosensitivity of iron chelates a further possibility arises, namely, that reduction takes place within the plant leaves, to give the less-stable ferrous compound (log K = 14·2 [5]). Then the iron in this form could be removed more readily by complex-formation with proteins or could be replaced by some other metal ions, for example, copper and zinc.

Further experiments are in progress to test the significance of the photosensitivity of iron chelates in plant nutrition and these will be reported later.

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Deposit of Spheroidal Graphite

The superior mechanical properties of nodular cast iron, in comparison with other cast iron, are believed to be due to the graphite which is present in a spheroidal form. Small additions of various metals, and suitable heat treatment, induce or inhibit the formation of this variety of graphite, and recently the presence of hydrogen in the gas atmosphere has been demonstrated to have a marked influence[1]. No generally accepted explanation of this phenomenon has been advanced; but several investigators have suggested that the presence of foreign particles is necessary in order to induce nucleation or growth of the spherulites by an epitaxis or by screw dislocation mechanism[2].

During experiments whereby small samples of refractory materials were heated in a wire-wound mullite tube furnace in a moisture-free town's-gas atmosphere at temperatures varying from 1,100° to 1,600° C., the samples were found to be coated with

Fig. 1. Typical filament. × 315
Fig. 2. Longitudinal section of a filament. × 350 (reflected light, crossed nicols)
Fig. 3. Cross-section of botryoidal structure. × 720 (polarized light)
Fig. 4. Cross-section of individual sphere. × 720 (polarized light)

a deposit of graphite which was composed entirely of spheroids in botryoidal and filamentous aggregates. Microscopic examination revealed that the filaments were composed of a string of spheres or sections of spheres, remarkably similar to the spherulites in the nodular cast iron[3].

Fig. 1 shows a typical filament and Fig. 2 shows a longitudinal section. Figs. 3 and 4 are cross-sections of a botryoidal structure and of an individual spheroidal structure respectively. On the surface of many of the spheres, spiral structures were observed and photographed. These were particularly abundant in the botryoidal masses.

X-ray examination gave a pattern of graphite.

We are grateful to the Ministry of Supply, and to Dr. A. T. Green, director of the British Ceramic Research Association, for permission to publish this communication.

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Oct. 15.

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Geological Ages of Witwatersrand Uraninites

The origin of the gold and the uranium in the conglomerates of the Witwatersrand system is a much-disputed problem. Two main schools of thought seem to have emerged, namely, the adherents to a placer hypothesis and those who support a hydrothermal theory of origin. Geological age determinations on Witwatersrand uraninites would yield valuable information to geologists concerned with this problem, since it is universally agreed that this system is of sedimentary origin and a maximum possible age for the system as a whole can be arrived at from field observations.

Davidson[1] undertook an age study on a sample of Witwatersrand uraninite by the lead-isotope method and obtained age values which at first could not satisfy the requirements of a hydrothermal theory of origin unless the Witwatersrand system was about twice as old as geologists were willing to believe, and thus considerably older than any other known sedimentary system. Subsequent geological age determinations on this same sample were made by J. L. Kulp[2,3] and Collins, Farquhar and Russell[4]. Further views on these results by Davidson[5] tend to reconcile the calculated most probable age with a hydrothermal theory of origin, which required a uraninite age younger than the possible maximum age of the sedimentary system. Geologists possessing an intimate knowledge of the Witwatersrand put the maximum possible age of this system at about 1,000 million years, whereas the age calculations of Davidson have successively decreased the most probable age from about 1,700 million years to between 465 and 816 million years. These figures were arrived at without undertaking a further study of more uraninite samples from this system.

The Witwatersrand system, in the type area, is some 25,000 ft. thick and its horizontal extent stretches over a 'strike' of about 150 miles. For this reason, no far-reaching conclusions should be drawn from the results of the study of a single, isolated sample of uraninite concentrate.

I have completed age analyses on ten samples of uraninite concentrates, three 'carbon' (thucholite) concentrates and two samples of uranium-rich 'carbon' ores according to the lead-isotope method, in conjunction with which four galena samples were analysed for their lead isotopic patterns. The samples were chosen to represent almost all the different recognized series of the system, and in horizontal extent the entire existing mining area was covered. A study of the patterns of apparent ages calculated from the RaG/UI, AcD/AcU and the AcD/RaG relations indicated that in most cases a loss of radon of between 5 and 27 per cent should have occurred, while in other cases the discrepancies in apparent ages of a particular sample could be explained by assuming a loss of uranium, or a loss of lead, or additions of old radiogenic lead, sometimes in addition to loss of radon. These conclusions were drawn after the manner of Holmes[6]. It is thus clear that the Witwatersrand uraninites are, strictly speaking, unsuitable material for accurate age determinations.

Nevertheless, a study of the apparent ages and radiogenic lead-isotope patterns found for the suite of samples as a group indicates that all the uraninites of the Witwatersrand system proper probably have the same geochemical and mineralogical history. The results seem to justify the conclusion that all these uraninites have a true age of between 1,850 and 1,950 million years, and that this mineral was therefore introduced into the Witwatersrand sedimentary beds as a detritus, being derived by an erosion process from an ancient source. Evidence of some form of reworking in the sedimentary system, after its deposition and consolidation, is proved by the admixture of radiogenic lead found in a galena which occurred as isolated large and perfect crystals and by the signs

Table 1

Sample	Pb^{204}/Pb^{total} (per cent)	Estimated radiogenic Pb (per cent)	AcD/RaG (per cent)	t_{UI}	t_{AcU}	$t_{\frac{AcD}{RaG}}$	Preferred age. (Figures in brackets doubtful)
Black Reef 'carbon'	1·03	59·9	15·74	2,044	2,254	2,460	(2,000–2,400)
Western Reefs uraninite	0·198	89·7	13·38	1,391	1,727	2,180	(1,730–2,180)
Western Reefs 'carbon'	0·333	83·7	14·98	1,668	1,997	2,375	(2,000)
Marievale uraninite	0·60	73·6	12·27	1,304	1,595	2,035	(2,035)
Marievale 'carbon'	0·73	68·0	12·41	2,199	2,121	2,050	(2,050)
Freddies uraninite	0·45	68·3	12·02	1,128	1,456	2,000	(2,000)
Wit Nigel uraninite	0·18	86·7	11·50	1,182	1,443	1,900	(1,900)
Sub Nigel uraninite (*a*)	0·08	94·1	13·79	1,612	1,875	2,215	1,875
Sub Nigel uraninite (*b*)	0·14	89·2	13·75	1,566	1,864	2,230	1,864
Blijvooruitzicht uraninite	0	100	12·29	1,825	1,913	2,020	1,913
Blijvooruitzicht 'carbon'	0·075	95·5	12·48	2,101	2,072	2,060	(2,000–2,100)
Babrasco 'carbon'	0·40	79·2	13·50	1,782	1,973	2,195	(1973)

of loss of uranium from some uraninites found in 'carbon'.

Uraninite from the Black Reef, which is composed of the erosion products of the Witwatersrand system, indicated a loss of uranium, which implied that the mineral was unable completely to survive this secondary erosion process. The survival of the original uraninites during their alluvial transportation period may, however, be explained if it is postulated that the earth's atmosphere at the time of the deposition of the Witwatersrand system was of a reducing (or at least a neutral) nature (with all the geochemical implications of such a postulate) as opposed to the oxidizing nature of the present atmosphere. According to Urey[7], the postulated transition could have occurred not much later than about 800 million years ago.

Some of the most pertinent data obtained in this study are given in Table 1, where the samples are arranged in stratigraphical order and ages are given in millions of years.

A full account of this work and a more complete discussion of the reliability of the results and their implications will be published in the forthcoming issue of the *Transactions of the Geological Society of South Africa*, **57**.

I wish to acknowledge the services of the analytical chemist, Mr. F. W. E. Strelow, of the South African National Chemical Research Laboratory, and the assistance of Drs. L. T. Nel, B. Wasserstein, D. J. Simpson, W. R. Liebenberg and R. A. Pelletier in valuable discussions and the supply and mineralogical processing of samples.

This note is published by permission of the South African Council for Scientific and Industrial Research.

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Oct. 12.

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Proposal for a New Æther Drift Experiment

Furth[1] has recently suggested a repetition of the Michelson–Morley experiment using microwaves and attempting to detect the change in resonant frequency of a cavity as it is rotated through 90°. Essen[2] proposes that any change in the resonant frequency of the cavity be detected by using the cavity to control an oscillator the frequency of which is compared with that of a quartz standard, and estimates that a change in resonant frequency of one part in 10^{10} might be detectable.

If instead of the cavity being used to control the oscillator frequency, as in Essen's method, it is used to produce a phase change in a signal from a fixed-frequency oscillator, greater sensitivity can be obtained.

The method is demonstrated in principle in Fig. 1. The output of an oscillator operating at the resonant frequency of the cavity is split into two

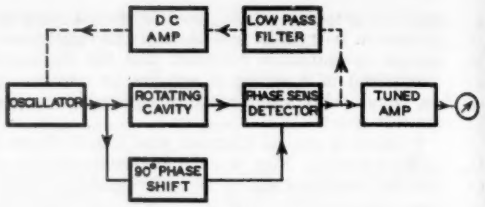

Fig. 1

branches, one of which contains the rotating cavity, the other a broad-band 90° phase-shifter. These two branches feed a phase-sensitive detector followed by a tuned amplifier and output indicator. The auxiliary feedback circuit shown in dotted lines maintains the oscillator at the mean resonant frequency of the cavity. As will be shown later, this refinement may not be necessary.

Let a rotation of the cavity through 90° produce a change Δf in the resonant frequency of the cavity, which is assumed to be resonant initially at the oscillator frequency f. Then the change in phase $\Delta\varphi$ on passing through the cavity will be $\Delta\varphi = 2Q \cdot \Delta f/f$, Q being the quality factor of the cavity. Thus, since we are dealing with very small values of $\Delta\varphi$, the detector output amplitude will vary as $\cos(\pi/2 + \Delta\varphi) \approx -(\Delta\varphi)$.

If the cavity is rotated continuously, then any effects due to æther drift will appear twice each revolution. Thus if the amplifier is tuned to twice the rotation frequency and has a narrow band-width, changes due to random drifts in frequency and to vibration, at other than twice the rotation frequency, will be eliminated. A suitable means of obtaining a narrow band-width would be the use of a synchronous rectifier switched at twice the rotation frequency, followed by a low-pass filter.

An estimate of the minimum detectable change in frequency $\Delta f/f$ may be made as follows. If the resonator output power is P_r, then the output of the detector will be $P \propto P_r(\Delta\varphi)^2$. Assuming the detector and amplifier have a noise factor N and band-width B, and that the minimum detectable power is equal to the noise power, the minimum detectable value of $\Delta f/f$ is:

$$\frac{1}{2Q}\sqrt{\frac{NkTB}{P_r}}, \qquad (1)$$

where k is Boltzmann's constant and T the absolute temperature. As an example, consider a 10,000 Mc./s. cavity of $Q = 10^4$, an input power to the detector $P_r = 10^{-3}$ W., a noise factor $N = 20$, a band-width $B = 1$ c./s., and temperature $T = 300°$ K. Then the minimum detectable value of $\Delta f/f$ is 5×10^{-12}, an improvement of 200 times on the method suggested by Essen. The value of N used here is appropriate to a superheterodyne system based on Fig. 1. For simplicity the frequency-changing stages have been omitted from Fig. 1. In principle, the sensitivity can be increased without limit by reducing the amplifier band-width B.

The basic advantage of the method suggested here over those which involve a measurement of frequency-difference is that it is a phase-difference between signals from the same source which is measured. Thus the stability of the source is not particularly important, provided that its frequency remains within a region less than f/Q. If the input signal is such that a phase difference of φ occurs in

the cavity, and rotation of the cavity produces a further periodic phase change $\Delta\varphi$, then the detector output power is proportional to $[\sin(\varphi+\Delta\varphi)-\sin\varphi]^2 = [\cos\varphi \sin\Delta\varphi]^2$. Hence, when $\varphi < \pi/4$, the reduction in sensitivity is small. Because $\Delta\varphi$ is periodic, it will be amplified, whereas accidental changes in phase-angle uncorrelated with $\Delta\varphi$ will be suppressed.

While not strictly relevant to Furth's suggestion, it is worth noting that the method suggested here is applicable to experiments such as those of Wood, Tomlinson and Essen[3], if the cavity is replaced by a quartz resonator. This should result in a considerable increase in sensitivity because of (*a*) the higher Q obtainable, (*b*) the ability to apply larger powers to the detector, and (*c*) the lower noise figures realizable at lower frequencies. As an example, consider a quartz resonator with frequency 100 kc./s. having $Q = 2 \times 10^5$, $P_r = 10$ mW., and $N = 2$, other parameters being as before. The minimum detectable $\Delta f/f$ is approximately $2{\cdot}5 \times 10^{-13}$.

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Use of Soluble Filter Gauzes

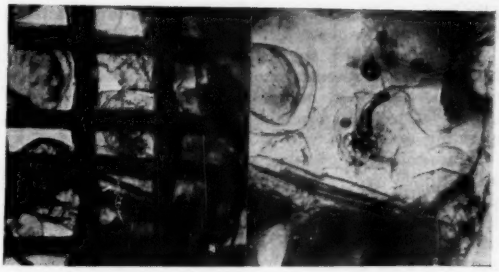
In connexion with filtration problems in agricultural spraying machinery, we have been making a study of the nature and quantity of matter in natural waters capable of being retained on filter gauzes. We found it necessary to develop a technique for this purpose which we think may be of interest in biological investigations.

Removal of the material from the gauze for microscopic examination is not satisfactory, as it cannot be assumed that a fair sample is removed or that delicate structures are not damaged. We therefore replaced the metal gauze by one of cellulose acetate, with the intention of dissolving away the filter base after transfer to a microscope slide. The filtered matter, mainly mineral and cellulose structures, could be left *in situ* undissolved and clearly visible.

To simulate 100-mesh wire gauze, an acetate fabric was kindly supplied by Messrs. Courtaulds consisting of 45-denier 10-filament (continuous) yarn with 30 turns to the inch woven with 92 warps and 84 wefts per inch.

400 ml. of water was found to give a convenient amount of deposit on a *B*14 cone (area = 0·44 sq. cm.). The part of the mesh containing the deposit was carefully cut out and mounted on a microscope slide. The presence of water on the yarn as well as in the organic matter gave rise to a cloudiness on dissolving the acetate mesh directly in acetone. It was therefore found necessary to dehydrate the specimen by successive washes in 30, 70 and 100 per cent ethanol before applying the acetone. The alcohol and acetone were introduced at the edge of the specimen and allowed to flow across by holding the slide obliquely. A cover slip was placed over the residue before the acetone had evaporated.

Figs. 1 and 2 are photographs of the same deposit taken before and after dissolving the filter. These



illustrate the greater detail visible when the filter is removed, both as regards absence of the fibres of fabric and also because of the greater ease with which the image can be focused. There is little disturbance of the disposition of the residue in the process except for some shrinkage in the diameter of filamentous matter and slight movement due to surface tension effects.

The colour of algae is sufficiently well retained during the solvent treatment to enable them to be clearly distinguished from colourless structures.

Thanks are due to Dr. G. S. Hartley for suggesting this method, and to the Board of Pest Control, Ltd., for permission to publish this work.

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Method for Recovery of Metallic Grids for Electron Microscopy

The metallic grids used as supports for the parlodion films containing material for electron microscopy are usually rejected after use. Good results in recovering these grids were obtained by the use of the following technique, which is a modification of one previously described[1].

Initially, the grids are washed with hot distilled water to dissolve soluble salts. The film of oil from the diffusion pump is removed by boiling the grids in a 0·1 per cent soap or any detergent solution for half to one hour and leaving them to stand in contact with the soap solution for a day at room temperature. The soap is then removed by washing with hot distilled water, followed by another washing with acetone to ensure complete removal of any residual oil. After treatment with acetone, the grids are placed in contact with approximately 1 *N* hydrochloric acid solution at 30–40° C. to remove the products of corrosion of the grids. The time of contact with the acid solution depends on the metal (less for copper and more for nickel grids) and also on the degree of corrosion. Generally, after no more than ten or twenty minutes, all grids present a clear bright surface and the acid solution can be poured off. The clean grids are then carefully washed with boiling distilled water to remove all traces of acid and dried at 100–120° C. protected from dust. The cleanliness of the grids can be checked by optical or electron microscopical examination, but it is not necessary. It was found that a small can, open on the top and having about twenty holes drilled in the bottom, is very convenient for washing the grids with water and acetone. Gener-

ally, ten washings were sufficient to ensure complete removal of the cleaning solutions.

The more dilute solutions of soap and especially of hydrochloric acid give better results than concentrated ones, as described before[1], because no close control of the time of contact between the grids and the cleaning solutions was necessary.

This method of cleaning used grids has some advantages over the flambage cleaning method proposed by Eaves[2], because it does not make them friable nor does it destroy copper grids, as pointed out by Eaves; however, it does involve much more material and time.

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[1] Souza Santos, P. de, *Ciencia e Cultura* (*Sao Paulo*), **4**, 46 (1952).
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Use of Methyl Cellulose Gel as a Substitute for Agar in Tissue-Culture Overlays

In the course of experiments designed to assay non-cytopathogenic animal viruses by Dulbecco's plaque-count method[1] using fluorescent antibody[2] to identify the plaques, a non-fluorescent substitute was required for the agar used in the overlay. Methyl cellulose has been used by Earle[3] to increase the viscosity of tissue-culture fluids for suspended-cell cultures, and appears to be harmless to animal tissue. An investigation of its properties showed it to be capable of forming highly viscous aqueous solutions which would gel spontaneously on raising their temperature. The presence of salts at physiological concentrations lowers the temperature of gelation. Thus one can make a solution of methyl cellulose containing tissue nutrients which, after being added as a liquid at room temperature to the tissue, will set quite firmly soon after being placed in an incubator at 37° C. A further advantage is that this overlay can be removed entirely without disturbing the tissue; this is achieved by cooling the culture in a refrigerator for a short time, during which the gel liquefies, enabling it to be removed by pipetting.

The following procedure was used for obtaining 'bare' plaques of fowl-plague virus entirely free from overlay. Petri-dish tissue cultures of chick tissue monolayers were made by Dulbecco's method[1], and infected; 5 ml. of 1·5 per cent methyl cellulose overlay was poured on to each infected plate and incubation continued for a further three days. The overlay was prepared as follows: 1·5 gm. methyl cellulose of 4,000 centipoises viscosity (Dow Chemical Co.) (previously thoroughly washed with alcohol and ether) was added to 15 ml. de-ionized distilled water at 100° C. in a 250-ml. conical flask. The flask was shaken to disperse the methyl cellulose (which is insoluble at this temperature) and immediately autoclaved. After removal (still hot) from the autoclave, a warm sterile mixture of 5 ml. four-fold Earle's saline[4] and 80 ml. synthetic medium (Waymouth, C., personal communication) containing antibiotics was added and thoroughly mixed. On cooling rapidly with agitation, the methyl cellulose dissolved to give a clear viscous solution. This was stored frozen at − 20° C.

Following incubation of Petri-dish cultures, the overlay was pipetted off after adding 10 ml. of phosphate-buffered saline at 0° C. to each plate, and chilling for ½ hr. The cultures were rinsed with more phosphate saline and were then available for staining for 10 min. with vital stain, or other treatment.

Under this overlay, plaques due to fowl plague virus take three days to become visible, whereas under agar only two days are required. This is believed to be due to a lower rate of diffusion of the virus in the methyl cellulose overlay; tests have indicated that the latter has no inhibitory or inactivating effect upon this virus.

Advantages of methyl cellulose overlay over agar are: (1) non-fluorescence; (2) simpler handling after a stock is made up; (3) overlay can be completely removed; (4) complete absence of toxicity on cells.

Disadvantages of the method are: (1) plaques take longer to form; (2) stock solutions are more difficult to prepare; (3) gel is much weaker than that obtained with agar of equivalent concentration.

A few experiments have been made with methyl cellulose gel for other uses in tissue culture. It may be used as a substitute for plasma clot, but seems inferior to the latter as judged by the rate of increase in size of outgrowths from explants. Tests indicate that such gels have useful applications in bacteriology; these are under investigation.

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Preservation of Dogfish

In institutions where dogfish are used for dissection, the preservative most commonly employed is a solution of formaldehyde in water. Formaldehyde is a good preservative; but its volatile and pungent character makes its use in the class-room and the store-room a matter of disagreeable compulsion.

Experiments first started in 1939 to find a suitable storage fluid to replace formaldehyde showed that pine oil compounds possessed many advantages in checking the growth of bacteria and fungi. 'Perminal KB' is a pine oil emulsion produced by Imperial Chemical Industries, Ltd., to assist in the kier boiling of cotton—as a solvent for fats and waxes, and as an emulsifying agent. When diluted with water it is an excellent preserving fluid for dogfish which have been fixed in formaldehyde. The steps are as follows: (1) wash the fixed dogfish in water overnight to remove the formaldehyde; (2) place in 'Perminal KB' 10 c.c., water 90 c.c.; rinse the specimens under the tap before dissection.

Dogfish so treated have been kept in this solution for more than five years without evidence of deterioration; but it should be emphasized that this method is of use only with fixed material. Fresh, unfixed material placed in this solution will decompose.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 21

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. A. A. L. Caesar: "Economic Planning of Eastern Europe".

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the Lecture Theatre of the Science Museum, South Kensington, London, S.W.7), at 5.30 p.m.—Mrs. J. M. Eyles: "Thomas Charles Hope and his Geological Lectures".

INSTITUTE OF PETROLEUM (at 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. P. Leicester: "The Modern Planning of Regional Surveys for Petroleum".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Commander C. G. Forsberg, R.N., and Mr. G. G. MacNeice: Informal lecture on "The Recent Search for and Salvage of the Comet Aircraft near Elba".

SOCIETY OF CHEMICAL INDUSTRY, PESTICIDES GROUP (in the Rooms of the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Meeting on "Vacuum Fumigation". Mr. W. Burns-Brown: "Physico-Chemical Effects"; Mr. A. B. P. Page: "Biological Effects".

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Dr. James Henderson: "From Sixth Form to University—Problems and Dilemmas".* (From a series of lectures on "Looking Forward in Education".)

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (at the Royal Institution, 21 Albemarle Street, London, W.1), at 6 p.m.—Dr. James Taylor: "The Progressing of New Projects from the Laboratory to the Plant" (Jubilee Memorial Lecture).

Tuesday, February 22

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.2), at 1.15 p.m.—Dr. R. P. Kelvin: "Missing the Point in Psychology".*

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, Westminster, London, S.W.1), at 5.30 p.m.—Mr. A. M. Muir Wood: "Folkestone Warren Landslips—1948–1950 Investigations"; Mr. N. E. V. Viner-Brady: "Folkestone Warren Landslips—Remedial Measures, 1948–54".

UNIVERSITY OF LONDON, BRITISH POSTGRADUATE MEDICAL FEDERATION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Prof. A. C. Frazer: "Fat Metabolism".* (From a series of lectures on "The Scientific Basis of Medicine".)

UNIVERSITY OF LONDON (in the Geology Lecture Theatre, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7), at 5.30 p.m.—Prof. L. U. de Sitter (Leiden): "Strain of Rock as determined in the Laboratory".* (First of three lectures on "The Strain of Rock in Mountain-Building Processes". Further lectures on February 25 and 28.)

ASLIB (at the Royal Society of Arts, 8 John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Mr. Jack Bird: "A New Look at Library Literature, or Why Write about Information Work?"

SOCIETY FOR ANALYTICAL CHEMISTRY, MIDLANDS SECTION (at the University, Edmund Street, Birmingham 3), at 7.15 p.m.—Inaugural meeting. Dr. D. W. Kent-Jones: "Developments in the Society for Analytical Chemistry".

Wednesday, February 23

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. F. C. Bawden, F.R.S.: "Virus Diseases of Plants" (Fernhurst Lecture).

PHYSICAL SOCIETY, COLOUR GROUP (at the Institute of Ophthalmology, Judd Street, London, W.C.1), at 3.30 p.m.—Mr. T. H. Vinnicombe: "The Robbialac Colorizer Method of Paint-Colour Mixing and its Value to All Concerned in the Usage of Colour".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. R. G. West and Mr. J. J. Donner: "The Glaciations of East Anglia and the East Midlands; a differentiation based on Stone Orientation Measurements of the Tills".

ROYAL SOCIETY OF MEDICINE, ENDOCRINOLOGY SECTION (at 1 Wimpole Street, London, W.1), at 5 p.m.—Discussion on "Hormones and Cancer". Opening Speakers: Sir Stanford Cade and Sir Charles Dodds.

INSTITUTION OF ELECTRICAL ENGINEERS, SUPPLY SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. A. Rusck: "High-Voltage Transmission Developments in Sweden".

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. R. K. Vinycomb: "A Versatile Electronic Engine Indicator".

SOCIETY OF CHEMICAL INDUSTRY (joint meeting of the FOOD and MICROBIOLOGY GROUPS, in the Rooms of the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Mr. D. H. F. Clayson: "Food Perishability in Terms of Micro-ecology".

ROYAL INSTITUTE OF CHEMISTRY (at Norwood Technical College, Knights Hill, West Norwood), at 7 p.m.—Dr. Tudor S. G. Jones: "Chromatography: Theory and Some Applications".

Thursday, February 24

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. Wilson Smith, F.R.S., Mr. G. Belyavin and Mr. F. W. Sheffield: "The Host Tissue Component of Influenza Viruses"; Mr. R. Halliday: "The Absorption of Antibodies from Immune Sera by the Gut of a Young Rat".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. A. G. Walker: "Tangent Planes".

INSTITUTE OF REFRIGERATION (at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Mr. G. Yate Pitts: "Sub-soil Temperatures and Frost-heave".

UNIVERSITY OF LONDON, BRITISH POSTGRADUATE MEDICAL FEDERATION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Dr. R. A. Kekwick, "The Plasma Proteins".* (From a series of lectures on "The Scientific Basis of Medicine".)

Friday, February 25

ASSOCIATION OF APPLIED BIOLOGISTS (at Imperial College, Imperial Institute Road, London, S.W.7), at 10.45 a.m.—Scientific Papers.

ROYAL METEOROLOGICAL SOCIETY (joint meeting with the ROYAL ASTRONOMICAL SOCIETY, at Burlington House, Piccadilly, London, W.1), at 2.30 p.m. Discussion on "Hydrodynamical Processes in Meteorology and Geophysics".

PHYSICAL SOCIETY (in the Lecture Theatre, Science Museum, South Kensington, London, S.W.7), at 5 p.m.—Dr. W. S. Stiles: "The Basic Data of Colour-Matching and some related Aspects of Visual Theory" (Thomas Young Oration).

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. Eric Ashby: "A Procession of Flowers".

Saturday, February 26

ASSOCIATION OF SCIENTIFIC WORKERS (in co-operation with the EDUCATION COMMITTEE of the LONDON CO-OPERATIVE SOCIETY, at the Central Hall, Westminster, London, S.W.1), at 2.30 p.m.—Prof. C. H. Powell, F.R.S.: "The H-bomb".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SENIOR BIOLOGIST, IN THE CHIEF ENGINEER'S DEPARTMENT, British Electricity Authority, to take charge of a small biological laboratory situated in North London and undertake research and advise the Authority on the effects of power station operation upon the life of rivers and other waterways—Director of Establishments, British Electricity Authority, Winsley Street, London, W.1, quoting AE/568 (February 25).

SCIENTIFIC OFFICER (with a first- or second-class honours degree in engineering or equivalent qualification, and workshop training or apprenticeship) in the Department of Scientific and Industrial Research, Low Temperature Research Station, Cambridge (after one year's training at Torry Research Station, Aberdeen) for research in refrigeration, processing and handling of meat—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.43/5A (February 26).

LECTURER IN APPLIED MATHEMATICS—The Registrar, King's College, Newcastle-upon-Tyne (February 28).

LECTURER (with a university degree in physical chemistry or chemical engineering) IN CHEMICAL ENGINEERING—The Registrar, King's College, Newcastle-upon-Tyne (February 28).

RIVER INSPECTOR (corporate member of the Royal Institute of Chemistry and of the Institute of Sewage Purification, or other appropriate qualifications)—The Clerk, Lothians River Purification Board, City Chambers, High Street, Edinburgh (February 28).

I.C.I. RESEARCH FELLOWS IN PHYSICS, CHEMISTRY, ENGINEERING, METALLURGY and PHARMACOLOGY, or any related subject, and LEVERHULME POSTGRADUATE FELLOWS (2) IN THE FACULTY OF SCIENCE—The Registrar, The University, Liverpool (March 1).

READER IN EXPERIMENTAL PHYSICS at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 3).

SENIOR SCIENTIFIC OFFICER (with a degree in physics or engineering, and experience in the design and development of lenses, and the supervision of a small optical workshop) in the Department of Supply, Weapons Research Establishment, Salisbury, South Australia, to undertake the design and development of optical systems for special purpose cameras and optical instruments—The Senior Representative, (A.P.27), Department of Supply, Australia House, Strand, London, W.C.2 (March 3).

LECTURER IN ANGLO-SAXON ANTIQUITIES AND ARCHÆOLOGY—The Secretary, University of Durham, 38 North Bailey, Durham (March 5).

CHAIR OF APPLIED SCIENCE, with special reference to engineering, tenable at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 7).

CIBA FELLOW IN CLINICAL PHARMACOLOGY, to develop techniques for the clinical evaluation of drugs where suitable techniques are not already available—The Secretary of University Court, The University, Glasgow (March 12).

LECTURER IN CHEMISTRY (Organic Chemistry)—The Secretary of University Court, The University, Glasgow (March 12).

LECTURER IN ENGINEERING—The Secretary, The University, Aberdeen (March 12).

Cereal Technician (with intermediate B.Sc. or equivalent qualification, and preferably with a science background) at the Agricultural Research Institute, Wagga, Australia, to be responsible for the technical work involved in the assessment of wheat quality including laboratory milling, tests on dough quality and experimental bread making—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (March 14).

Assistant Lecturer in Physics—The Secretary and Registrar, University College of North Wales, Bangor, North Wales (March 15).

Assistant Lecturer in Theoretical Physics—The Registrar, The University, Manchester (March 16).

University Lecturer in Agricultural Zoology and Physiology of Farm Animals, and a University Demonstrator in Agricultural Entomology—The Secretary, School of Agriculture, Downing Street, Cambridge (March 16).

Research Officer (with a university honours degree in science, with chemistry, botany or biochemistry as major subjects, and preferably some research experience in mycology) in the Biochemistry Unit, Wool Textile Research Laboratories, Melbourne, Australia, to take part in a programme of research on cellulose-destroying fungi with special reference to the nutritional requirements of particular moulds, the nature of the enzymes produced and their mode of action on cellulose—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 462/69 (March 19).

Head of the Department of Entomology—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (March 31).

Lecturer in Applied Mathematics—The Secretary and Registrar, The University, Southampton (March 31).

Technical Assistant (graduate, whose degree course included mathematics and/or physics, and a knowledge of a modern continental language) in the School of Theoretical Physics—The Senior Clerk, Dublin Institute for Advanced Studies, 64 Merrion Square, Dublin (March 31).

Scientific Officer (with a first- or second-class honours degree in an approved scientific subject or other approved qualifications, and preferably with industrial experience) in the Department of Industrial and Forensic Science of the Ministry of Commerce—The Secretary, Civil Service Commission, Stormont, Belfast, N. Ireland (April 1).

Director (with high attainments in one of the basic sciences relevant to the work of the Institute, and preferably with experience of horticultural crops) of the Glasshouse Crops Research Institute—The Secretary, Glasshouse Crops Research Institute, Worthing Road, Rustington, Sussex (April 15).

Lecturer in Applied Mathematics, and a Lecturer in the Department of Civil Engineering, at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Cape Town, April 15).

Senior Lecturer (with a higher degree, for example Ph.D. or equivalent qualifications, and preferably with lecturing experience) in Physics at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (June 15).

Biologist (preferably with an honours degree in zoology or one of the natural sciences) in the Department of Game and Tsetse Control, Northern Nigeria, for duties which include the administration of game conservation and control, with study of animal ecology generally, the habits of individual wild animals, significance of wild animals to tsetse and diseases of stock—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.152/3/01.

Chemical Technician (preferably with experience in a biological laboratory) in the Radioisotope Laboratory at the Pollards Wood Research Station, Chalfont St. Giles, Bucks—The Institute of Cancer Research, Royal Cancer Hospital, Fulham Road, London, S.W.3, quoting "Chemical Technician".

Experimental Officers (preferably with a pass degree in chemistry and experience in microchemical analytical techniques) to assist in basic research in inorganic chemistry and metallurgy—Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 512/WGE/34.

Lecturer (preferably with an honours degree in agriculture, horticulture or engineering, and experience in teaching and research) in Farm Mechanization and Agricultural Engineering—The Registrar, Wye College, near Ashford, Kent.

Lecturer (with industrial engineering experience and also experience in research) in Mechanical Engineering—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1.

Master to teach Botany and Zoology in the Sixth Forms—The Headmaster, St. Dunstan's College, London, S.E.6.

Mathematicians (with a first- or second-class honours degree in mathematics, and preferably some research experience in an applied field) at various Ministry of Supply Research and Development Establishments in Southern England—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.28/5A.

Scientific Officers (with a first- or second-class honours degree or equivalent in mathematics or mathematical physics), at the Royal Aircraft Establishment, Farnborough, Hants, for research and development on targets for guided weapons—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.36/5A.

Scientific Officers (with at least a first- or second-class honours degree in chemistry, and preferably with research experience in physical chemistry), for basic research in inorganic and metallurgical chemistry—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 511/WGE/34.

Senior Experimental Officer or Experimental Officer (with at least H.S.C. in physics or equivalent qualification in electrical engineering, and preferably with experience of metal vacuum systems and/or high voltage equipment), to take charge of the running, maintenance and improvement of a high voltage ion accelerator used for nuclear physics research—The Establishments Officer, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting 2/103/233.

Senior Experimental Officer (with at least H.S.C. (science) or equivalent, and several years appropriate experience in an industrial laboratory), at Sellafield, Cumberland, to undertake experimental work in metallurgy and physics—United Kingdom Atomic Energy Authority, Industrial Group Headquarters, P.O. Box 19, Risley, Warrington, quoting 797.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Department of Scientific and Industrial Research. Fire Research—Technical Paper No. 2: Report of Committee on Vapourizing Liquid Extinguishing Agents. Pp. vi+14. (London: H.M. Stationery Office, 1954.) 1s. net. [712

City of Leicester Museum and Art Gallery. 48th Report to the City Council—1st April 1953 to 31st March 1954. Pp. 46+4 plates. (Leicester: City of Leicester Museums and Art Gallery, 1954.) [712

Colonial Office. Colonial Research Studies No. 14: The Land Dayaks of Sarawak—a Report of a Social Economic Survey of the Land Dayaks of Sarawak, presented to the Colonial Social Science Research Council. By Dr. W. R. Geddes. Pp. 113+4 plates. (London: H.M. Stationery Office, 1954.) 32s. 6d. net. [712

Ministry of Pensions and National Insurance. Digest of Statistics Analysing Certificates of Incapacity, 1951 and 1952. Pp. 21+92 tables. (London: Ministry of Pensions and National Insurance, 1954.) [712

Bulletin of the British Museum (Natural History). Entomology. Vol. 3, No. 12: The Genera *Henricohahnia* Breddin, *Dieradelus* Ericson, *Nyllius* Stål, *Orgetorixa* China and Allied New Genera. By N. C. E. Miller. Pp. 445–488. 12s. 6d. Zoology. Vol. 2, No. 10: The Otariid Seals of the Pacific Coast of America. By Judith E. King. Pp. 309–337+plates 10 and 11. 8s. (London: British Museum (Natural History), 1954.) [912

Other Countries

Conseil Permanent International pour l'Exploration de la Mer, Charlottenlund Slot, Danemark. Bulletin Hydrographique pour l'Année 1950. Publié par Le Bureau du Conseil, Service Hydrographique. Pp. x+114. (Copenhague: Andr. Fred. Høst et Fils, 1954.) 40 kronor. [3011

United States Department of Agriculture. Technical Bulletin No. 1091: The Larvae and Pupae of the Mosquitoes belonging to the Culex Subgenera Melanoconion and Mochlostyrax. By Richard H. Foote. Pp. ii+126. 50 cents. Leaflet No. 370: The Seed-corn Maggot: How to Control It. Pp. 6. 5 cents. (Washington, D.C.: Government Printing Office, 1954.) [712

Tanganyika. Records of the Geological Survey of Tanganyika. Vol. 1, 1951. Pp. v+80+9 plates. 7/50 shs. Geological Survey Department. Bulletin No. 21: Geology of the Ketewaka-Mchuchuma Coalfield, Njombe District. By A. C. M. McKinlay. Pp. v+46+4 plates. 12 shs. (Dar-es-Salaam: Government Printer, 1954.) [712

University of Natal. Wattle Research Institute (South African Wattle Growers' Union—University of Natal—Union Department of Forestry). Report for 1953–1954 (Seventh year). Pp. 58. (Pietermaritzburg: University of Natal, Wattle Research Institute, 1954.) [712

Kungl. Sjökarteverket, Stockholm. Ergebnisse der Beobachtungen des Magnetischen Observatoriums zu Lovö (Stockholm), im Jahre 1951. Von Nils Ambolt. Pp. 30. Ergebnisse der Beobachtungen des Magnetischen Observatoriums zu Lovö (Stockholm), im 1954. Von Folke Eleman und Kjell Borg. Pp. 30. (Stockholm: Statens Reproduktionsanstalt, 1953 and 1954.) [712

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University College, Ibadan, Nigeria. Calendar, 1954–55. Pp. 36 (Ibadan: University College, 1954.) [912

University College of Khartoum, Sudan. First Annual Report of the Hydrobiological Research Unit, July 1953 to June 1954. Pp. 23 (Khartoum: University College, 1954.) [912

United States Department of Agriculture. Farmers' Bulletin No. 2074: American Foulbrood of Honey Bees: How to Control It. By A. S. Michael. Pp. 12. (Washington, D.C.: Government Printing Office, 1954.) 10 cents. [912

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